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CONTENTS

A SYMPOSIUM - -
THE ECOLOGICAL APPROACH TO LAND USE
—Edward H. Graham, Seymour E. Harris, and Edward A. Ackerman

THE REAL VALUES OF SOIL ORGANIC MATTER
—Firman E. Bear

SOIL CONSERVATIONISTS FOR ALL THE WORLD
—William X. Hull

THE BIOLOGY OF SOIL STRUCTURE
—T. M. McCalla

IS SPECIAL EQUIPMENT NEEDED FOR STUBBLE MULCH FARMING?
—L. G. Sambel

CONSERVATION NEEDS EDUCATIONAL AND ORGANIZATIONAL DRIVE
—R. K. Bliss

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CONTENTS

Editorial 54

A Symposium - - The Ecological Approach to Land Use 55

The Biologist's Viewpoint 55

The Economist's View of Land Use 59

The Geographic Meaning of Ecological Land Use 63

Is Special Equipment Needed for Stubble Mulch Farming? 67

The Biology of Soil Structure 71

Pictorial 77

The Real Values of Soil Organic Matter 81

The Effect of Cropping Systems on the Winter Population of Earthworms 85

Soil Conservationists for All the World 89

From the President 93

Conservation Needs Educational and Organizational Drive 95

Notes and Communications 97

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EDITORIAL

THIS issue of the JOURNAL contains a series of technical, informative, and thought-provoking articles. The content of each provides the basis for discussion, application, and further development in the field by the professional soil conservationist. This does not mean that each new fact or scientific development always originates in a laboratory or is the result of well-planned field work. Practical farmer experiences along with observations by conservationists have also contributed much to the success of the soil conservation movement.

Conservationists need to be alert to the ordinary happenings on the land. Practical farmer experiences in the field of soil conservation are needed to supplement research. These experiences often provide the key to a problem which otherwise would remain unsolved. Here is where the professional soil conservationist, working in cooperation with the farmer on the land, can make a practical contribution to the science of soil and water conservation.

It is hoped that soil conservationists will pass along to the JOURNAL their observations and findings; also their opinions of viewpoints expressed by others. The columns of the JOURNAL are open to members of the Society for comment and debate.

Educational Drive Is Needed

R. K. BLISS, Extension Agriculturist for the Iowa Extension Service, points out elsewhere in the JOURNAL that the conservation program needs "*educational and organizational drive to get everyone—farmers, city people, schools—interested in soil conservation.*" The leadership for this task is a responsibility of the Extension Service. But help is needed in counties and in soil conservation districts, in urban centers and in schools, to develop and organize an effective educational program.

Conservation education is not entirely a new term. A considerable amount of work has already been done in this field by state and federal agencies. In addition—and important too—private concerns representing agriculture, industry, commerce, the utilities, civic and professional groups, are almost daily releasing excellent conservation education materials. All this has been helpful to properly emphasize the need for conservation.

The number of individuals, groups, and private concerns that are becoming interested in conservation is increasing. This presents a real problem. These groups should be provided with the right kind of information on which they can build programs, otherwise their efforts will not be effective.

Expert guidance and leadership based on factual data and experience is needed. The professional soil conservationist, working with leaders in the field of education, is expected to provide the basic information. He cannot, therefore, overlook the fact that his is a responsibility of major concern.

More Than Technical Skill

THE soil conservationist worthy of his profession must have an historical perspective. Proficiency in techniques is not enough. The science of soil conservation demands more than technical skill. It also requires acquaintance with what is being done in related fields, familiarity with the way in which soil conservation work relates to the general welfare, and knowledge of how the subject has developed through the ages. Knowing something about the thought given to proper use of the land throughout historical time is prerequisite to the soil conservationist's full understanding of his sphere of endeavor.

What did Xenophon, Theophrastus, Varro, Columella, Pliny, Vergil, and the ancients know about good husbandry and careful use of the land? What did Jethro Tull, George P. Marsh, Nathaniel S. Shaler, B. E. Fernow, P. S. Lovejoy, W. J. McGee, and many early American writers contribute to the science of soil conservation?

(*Continued on page 98*)

A Symposium*— —

THE ECOLOGICAL APPROACH TO LAND USE

The Biologist's Viewpoint

EDWARD H. GRAHAM

DR. GRAHAM is Chief of the Biology Division of the Soil Conservation Service, Washington, D. C. He is also author of *The Natural Principles of Land Use* and a co-author of *The Land Renewed.*

IN PRESENTING the biologist's point of view, it is not my intention to insist that the biological aspect of land use is the most important. The essence of the ecological approach is that all pertinent aspects of the subject be considered. Although one phase of land use may sometimes loom larger than another, it is the interdependence of all aspects of the problem that is significant. Man's relation to his environment —of which man himself is an inseparable part— is complex, more so today in the face of modern civilization than ever before. We must try to see all phases of this relationship. Certainly there are many factors that have an important bearing on the way man uses the land.

Geographic position bears strongly upon land use, for with it are associated soil type, climatic influences, vegetation, physiography, and other environmental features. The early system of rectangular surveying has given us a pattern of square fields. To farm on the contour is thus complicated because of an element in our early history. Human culture has a distinct bearing upon the use that is made of the land. The "Pennsylvania Dutch" refused to sign agreements with the Government to apply soil conservation practices, not because they were not in favor of the practices, but because it was against the belief or mores of the people to enter into such contracts. The beautiful pattern of conservation farming now conspicuous in the landscape of southern Pennsylvania resulted because the Government yielded, not the "Pennsylvania Dutch." Economic considerations are significant in determining what must be done with land. A farmer cannot convert eroding cultivated slopes to pasture or woodland if there is no ready market to provide an income from the sale of livestock or wood products. Thus geographic, historic, cultural, and economic factors influence the use we make of the land.

But it is to still another important factor— the biological or ecological—that I wish to turn your attention. I hope to do this by asking you to look briefly at three relationships. They are: (1) The relation of insect and bird populations to strip cropping; (2) the relation between range condition and rodent numbers; and (3)

*This symposium, *The Ecological Approach to Land Use,* was presented before the American Academy of Arts and Sciences, Boston, Massachusetts, May 8, 1946, by a Biologist, an Economist, and a Geographer.

Conservationists will find each presentation challenging and stimulating. The authors have approached their subjects from the land point of view. They have thoroughly explored land use capabilities, world population in its relationship to available land, and the economic pressure on natural resources.

the classification of land according to use capabilities as a guide toward environmental adjustment. The lantern slides will graphically express much of what I wish to say.

STRIP CROPPING

The use of strips of clean-tilled crops alternating with strips of thick-growing crops is a soil and water conservation practice that has been so publicized as to become almost the symbol of soil conservation. Like every other conservation practice, it has its biological aspects. Until these aspects are understood the soil conservationist cannot recommend the practice without reservation. In some places strip cropping has been questioned because it increases damage from chinch bugs. These insects winter-over in strips of meadow or other thick-growing vegetation, ready to move the following season into the strip of corn that is adjacent to the close-growing crop.

There is another angle to the story, an angle brought into focus by land-use studies in Ohio. There, after careful evaluation, it was learned that more small birds were nesting in strip-cropped fields than in other fields. We do not know exactly why this is so. We do know, however, that in fields composed of alternating strips of corn, small grain, and meadow, there were approximately twice as many ground-nesting birds per acre as in non-stripped fields under otherwise apparently comparable conditions. Although some of the birds—grasshopper sparrows, vesper sparrows, meadow-larks—are seed eaters, they feed their young almost exclusively upon insects. Therefore, they must exert an effect upon harmful insects such as the chinch bug. Furthermore, other studies have shown that strip cropping increases the number of predacious insects which feed upon plant-consuming insects.

When a conservation practice like strip cropping increases an injurious insect, but at the same time increases the enemies of that species, one may reasonably ask: What is the biological resultant of forces generated by the application of the practice? The answer is not at hand. I state the case to illustrate a problem in the biology of land use. Not only strip cropping, but hedges, field border plantings, cover crops, crop residue management, green manures, use of new plants like kudzu (accused of increasing white-fringed beetle in Florida and Alabama), and many other soil and water conservation practices appear to have important biological aspects. We are only beginning to learn what they are, but the biological effects of land-use measures now being recommended for soil and water conservation must be understood before we can be sure those measures are thoroughly sound.

RODENTS AND RANGE CONDITION

The management of millions of acres of rangeland in the western United States is a major agricultural endeavor affecting both the land and our national economy. It has long been contended that inasmuch as prairie dogs, ground squirrels, kangaroo rats, and jack rabbits eat plants, they compete with cattle and sheep for range forage. The obvious course has been to try to exterminate the rabbits and rodents, so that domestic livestock can eat the vegetation the wild animals would otherwise consume. Large sums of money have been spent by the Federal Government, States, and local agencies in attempts to eliminate range rodents. The result has not always been improvement of the range, for poor range often continues its poor condition even where most of the rodents have been eliminated. The reason seems to be that the rodents are not the cause, but the result, of poor range condition, which in turn is due primarily to overgrazing by livestock.

Let us look at a specific example of rangeland in eastern Oregon. The condition of this range varies from place to place. Like other types of range, the vegetation in this area has responded to use, and it can be classified into four conditions—depending chiefly on the dominant plant species—as shown in Table 1.

The grasses most abundant when range of this type is in excellent condition are bunchgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), Junegrass (*Koeleria cristata*), blue-

TABLE 1.—RANGE CONDITION AND RELATED FACTORS (As generalized for bunchgrass range in eastern Oregon).

Condition	Composition	Accelerated Erosion	Est. Acres per Animal Unit Month	Rodent and Rabbit Numbers
Excellent	Grasses 95% Weeds 5%	None	One	Occasional
Good	Grasses 60% Weeds 40%	None	One and one-half	Few
Fair	Grasses 30% Weeds 70%	Slight	Two	Common
Poor	Grasses 10% Weeds 90%	Severe	Twelve	Abundant

grass (*Poa secunda*) and Nevada bluegrass (*Poa nevadensis*). The most common weeds are snakeweed (*Gutierrezia sarothrae*), cheatgrass (*Bromus tectorum*), balsamroot (*Balsamorhiza sp.*), yarrow (*Achillea lanulosa*), and annual fescues (*Festuca spp.*). There are several things about Table 1 that should be noted. First of all, excellent condition represents a very productive type of vegetation relatively stable under prevailing climatic conditions. The more heavily the range is grazed beyond the point of safe use, the lower in the scale it progresses, with weeds becoming more and more abundant. Degree of erosion can be correlated with range condition, most severe erosion usually occurring where the range is poorest. The number of cattle the range will support also shows a direct relationship to range condition.

From the standpoint of the biologist, it is significant that there exists a direct correlation between range condition and the occurrence of many species of rodents. Excellent range with a high percentage of perennial grasses generally supports relatively few rodents. Poor range, with many weedy plants, usually supports a great many rodents as well as large numbers of jack rabbits. This seems to be generally true, and we find Vorhies and Taylor, in University of Arizona Technical Bulletin 86, writing in 1940 as follows:

"As the grazing range deteriorates, in various parts of the Southwest, brush and small trees . . . cholla cactus and prickly pear tend to increase. The superior perennial grasses tend to be replaced by annuals . . . and numerous weeds become abundant . . . cottontails, cotton rats, meadow mice, harvest mice, and other species characteristic of thick grass tend to decrease, and jack rabbits, kangaroo rats, prairie dogs, ground squirrels, and wood rats . . . tend to increase."

It therefore seems evident that attempts to improve the range by poisoning or otherwise eliminating rabbits and rodents may well place the cart before the horse. The real solution to the rodent problem more likely rests in range improvement. Reducing the number of livestock, properly distributing stock watering facilities, and other range management methods will tend to change poor range to fair, fair to good, and good to excellent. With such change the more desirable grasses will appear and there will be a tendency to reduce erosion, ultimately increase livestock carrying capacity, and reduce the number of rodents and rabbits. The solution to the rodent problem, then, as suggested by a biological approach, is to change the environment by means of fundamental improvement in the condition of the range.

LAND CLASSIFICATION

One of the essential laws of biology is that an organism must be adapted to the conditions under which it occurs or it cannot survive. This is eminently true of man. If as a group we do not bring our land operations into adjustment with physical land conditions we can neither preserve the soil as a basic resource or use it profitably. We need guides for the use of the land, so that we know how every parcel should be used in accordance with its capacity for use. Based upon soil factors, slope, degree of erosion, and climate, a simple classification of land according to its suitability for use has been developed. It is shown in Table 2, and divides all land into eight classes.

In the United States there are more than a billion acres designated as land in farms. Estimates by the Soil Conservation Service indicate that of this acreage about 475 million acres are suitable for cultivation. This land is placed in

Classes I, II, and III. Some seventy million acres are in Class I, 170 million acres are in Class II, and 235 million acres are in Class III. There are nearly 95 million acres of Class IV land, suited for limited cultivation. Land not suited to crops but suitable for grass or trees—Classes V, VI, and VII—total about 440 million acres. Finally there are some 33 million acres of Class VIII land suited only for wildlife and recreation. The land not in farms—some 860 million acres—has not been classified according to use capability.

LAND SUITED FOR CULTIVATION

CLASS I: Very good land that can be cultivated safely with ordinary good farming methods. It is nearly level and easily worked. Some areas need clearing, water management, or fertilizing. Usually there is little or no erosion.

CLASS II: Good land that can be cultivated safely with easily applied practices, such as contouring, protective cover crops, and simple water-management operations. Common requirements are rotations and fertilizing. Moderate erosion is common.

CLASS III: Moderately good land that can be cultivated safely with such intensive treatments as terracing and strip cropping. Water management is often required on flat areas. Common requirements are crop rotations, cover crops, and fertilizing. Usually there is moderate to severe erosion.

LAND SUITED FOR LIMITED CULTIVATION

CLASS IV: Fairly good land that is best suited to pasture and hay but can be cultivated occasionally—usually not more than one year in six. In some areas, especially those of low rainfall, selected land may be cultivated more than one year if adequately protected. When plowed, careful erosion-control practices must be used.

LAND NOT SUITED FOR CULTIVATION

CLASS V: Suited for grazing or forestry with slight or no limitations; needs only ordinary good management.

CLASS VI: Suited for grazing or forestry with minor limitations; needs protective measures.

CLASS VII: Suited for grazing or forestry with major limitations; needs extreme care to prevent erosion or destructive burning, or to overcome other hazards.

CLASS VIII: Suited only for wildlife or recreation. This land usually is steep, rough, stony, sandy, wet, or highly erodible.

This idea of classifying land according to its suitability for use is fundamentally an ecological one. It identifies land types with a view toward bringing man into better balance with the environment in which he lives. It guides us in using land so that we can produce adapted crops in greatest amount without causing deterioration to the soil, thus preserving a suitable environment.

From the biologist's point of view it is noteworthy that this classification recognizes a use for every kind of land. Even steep, rough, stony, sandy, or wet land may have recreational value or produce a wildlife crop. Much wet land, in fact, is highly productive of special crops such as muskrats and waterfowl. Although other classes of land support wildlife, sometimes abundantly, patches of Class VIII land make ideal havens for quail, pheasants, raccoons, and other useful wild animals. Recognition and treatment of such lands assures yields of wildlife, and gives wildlife production, along with the production of timber, livestock, and cultivated crops, its rightful place among the major types of land use.

CONCLUSION

The contribution of the biologist to land use is hinted at, though by no means elaborated upon, by the examples given. Strip cropping in its influence upon insects and birds exemplifies the importance of looking to a biological evaluation of land-use practices if such practices are to be thoroughly understood and unreservedly recommended to land operators. The place of rodent control in range management illustrates the necessity of understanding the relationship between wild animals and the condition of land as it results from use. The concept of land classification according to capability for use shows the integration of ecological and biological phases along with other technical aspects of land management. Such examples illustrate the fundamental importance of biological considerations in the use and care of land, and indicate that the biologist or ecologist occupies an important place along with the geographer, historian, sociologist, economist, and other professional experts whose work relates in one way or another to use and management of the land.

The Economist's View of Land Use

SEYMOUR E. HARRIS

DR. HARRIS, of the Littauer School, Harvard University, is one of the country's leading economists. His work is well known among his professional colleagues and his opinions are valued in both government and business.

BOTH DR. ACKERMAN and Dr. Graham, whose discussions I saw in preliminary form, show clearly that there has been much wastage of our land resources and in particular a lamentable but presentable degree of soil erosion. The loss of top soil can be recouped only with the passage of many centuries. They have demonstrated also that planning for land use can make an important contribution toward an improved balance between man and available land resources.

The economist obviously is interested in these problems, and although the biologist and the geographer can make important contributions to the solution of these problems, the economist, too, has a responsibility. They all must work together with others—e. g., the political scientist—to solve these problems.

The source of much of our difficulties is the unsatisfactory time use of our resources. The cotton farmer, unmindful of the rights and interests of future generations in the use of top soil, takes what he can out of the soil and moves on. He leaves a trail of abandoned land, raped and valueless land, as he moves from Carolina to Georgia to Mississippi to Oklahoma, and finally to Texas and California. Similarly the oil man, pressed by 25 million automobile owners, takes the oil from the earth in a manner, however profligate, which will yield him the highest profit. He, too, is unmindful of the need of oil for his grandchildren, and indifferent as to whether the cost will be 25 cents or 25 dollars a gallon; and he is not concerned that today's jaunt to Nigeria may be at the expense of tomorrow's defense of his country.

To formulate a time pattern for the use of our natural resources requires answers to some questions. How much should the present generation be asked to give up to future generations? Are we taking an undue share of lumber, oil, iron and steel, topsoil, etc.? Are we exploiting our resources in a manner which can only be detrimental to John Jones born in 1950? Just before the war the United States, with a population of about two-thirds of the U. S. S. R., had a reserve of iron of but 48 tons per capita, as compared with 94 tons per capita for the U. S. S. R. Can we then justify 6 million new automobiles per year under these circumstances?

Our planners should have a blue print for 25, 50, and perhaps even 100 years. We clearly have a responsibility to plan for the next 25 or 50 years, and many would say for 100 years. We should make the best possible estimate of our resources; of the optimum allocation as between alternative uses and as between present and future uses. We shall indeed have to rely on guesses — informed guesses — as to population, age distribution, effects of new resources and improved technology, and the like. But an imperfect blueprint is better than none at all. Insofar as this planning can cross national boundaries so much the better. If we do not want to be charged with robbing our grandchildren and great-grandchildren of their national heritage, we had better get busy.

If we cannot get to first base in planning the use of today's resources, can we expect much success in planning the future allocation of resources? Our practice of allowing the individual, out for personal gain, to misuse economic resources, to set up business enterprise, etc., in a manner that increases his profits but reduces the net gains for society, is short-sighted and unintelligent. (The economist would say that in

such instances there is net marginal *private* gain but a net marginal *social* loss.) An example of this costly planlessness is the British industrial movement from S. E. to N. W. and then back again to S. E. The loss in terms of additional congestion, extra cost of social services, vulnerability to attack, can scarcely be overestimated. In Britain today, however, there is much evidence that the British are determined to bridle the selfishness of those who act exclusively in response to private gains.

The Malthusian spectre of overpopulation in relation to economic resources no longer stalks us. According to the Malthusians, the *tendency* of population to grow excessively would be corrected by starvation and losses due to war. Actually, events have not borne out these gloomy forebodings: we have had both large rises in population and phenomenal gains in our standards of living. In the period from the Civil War to World War II our national income rose about 11 times; and our per capita income, about 4 times. Apparently, for the present at any rate, this country has solved the problem of the relation of man to his natural resources—we had this large rise despite a large decline in the death rate and a very large rise in population. Our Number One economic problem seems to be one of providing demand for the goods produced, not the Malthusian problem of supply. To keep up demand sufficiently it seems increasingly difficult, given the rapid technological gains, to yield employment for all who wish to work. Our $150 billion income today requires 60 million workers; in 1900, it would have required 150 million workers; and by the year 2000, a good guess would be 20 to 30 million workers.

Our problem is not alone then the pressure on resources but also the support of demand. If we underwrite demand, say through public measures, we increase the pressure on our limited resources. We live and work today but deny our children their fair share of jobs and goods. What is the solution to this dilemma? A better husbanding of resources is clearly required.

We may have to learn to take our gains in a manner which results in less depletion of the soil—our gains of productivity can be taken increasingly in leisure; and in non-material goods: education, health, services. In that manner, we shall provide a fuller life, an acceptable distribution of available work, and shall exclude excessive use of our natural resources. A full employment program which requires an excessive use of our resources may, over a long period of time, prove to be a boomerang.

If we seem to have solved our problem, the world as a whole clearly has not. A comparison of income and population figures, at any rate, suggests this conclusion. Prior to the war, the United Kingdom, the United States, and Germany had 41 per cent of the world's income, and about 14 per cent of the world's population. Or, to be more graphic, the United States per capita annual income was 20 times as large as India's and almost 30 times that of China's, which was 18 dollars per head. India and China had about one-half the world's population, and only 13 per cent of the world's income.

Clearly there are too many people for the resources available in a large part of the world. The obvious solution is either to reduce the population, or to increase the resources. Other papers in this symposium have offered various proposals to make the resources go further. Provision of human food through the intermediary of animal husbandry is frequently wasteful and, as Dr. Ackerman observes, there are religious as well as other objections to this practice. If all the good advice offered by the other participants and indeed also by the Food and Agriculture Organization are followed, then we shall have better use of soil and more food made available.

Yet we are faced with two horns of a dilemma. Many are concerned not only over the inadequacies of supplies; but also over the excesses. Experts tell us that there is scarcely an agricultural crop which does not promise excesses within a few years—that is oversupply in the sense that a profitable price is not to be had by the farmer. At expected incomes, too much will be produced to yield a fair return to the tens of millions of farmers. And this in a world

with per capita income of $150 or less and with most inadequate diets for the masses. We have in the world starvation and excesses at one and the same time! This is an important problem in the study of land use.

How are we to deal with the problem of excess? A popular prescription is to increase world income; and at higher incomes there will be plenty of demand to take off the market what is produced by the farmers, and at profitable prices. The point is that technology advances too rapidly, given the relative immobility of the farmer. Despite falling prices and declining profits associated with expanding output, the farmer sticks to his farm, refusing to change his pattern of life. Not enough farmers move from the farm to the city.

The farm problem in this country, for example, is explained in no small part by the excessive numbers on the farms. Despite a net movement from farm to non-farm areas of 15 millions in the 24 years ending 1944, and despite a reduction in the working population engaged in agriculture from 42 per cent in 1890-91 to 15 per cent in 1944, the average net income per worker engaged in agriculture in 1940 was $531 and in 1944, $1,456, as compared with $1,273 and $2,360 for the industrial workers in these years, respectively.

Another proposal is to industrialize the agricultural countries. It is common knowledge that industrial countries have higher standards of living than non-industrial countries. In China, India, Eastern Europe, and Latin America, for example, there is a strong disposition to raise the standard of living through a greater emphasis on manufacturing. It is proposed that foreign capital be imported, that tariffs be imposed, and that excess population be moved from the farms to the cities. Undoubtedly, the income of non-industrial countries may be increased through diversion of resources into manufacturing. In part the gains may be associated with the greater effectiveness of men working with machines in industry than in agriculture, with or without machines. In part the gains are to be ascribed to the better supply-demand relationship for manufactured products than for food and raw materials. With more production in manufacturing at the expense of agriculture, the new participants in industry will gain. And if we are to have an improved world situation, then there must be a new balance between the increased output of manufactured goods and services on the one hand, and the increased output of agricultural products. The former should rise sufficiently to provide the demand for raw materials and food which assures reasonable prices; and yet should not rise so rapidly as to encourage wasteful use of resources or too rapid a movement away from the farms and inadequate production of basic raw materials.

A better balance between agricultural and industrial output is indeed desired; and increased industrialization in agricultural countries should help improve matters. Perhaps the $70 billion of foreign capital (the sum estimated by one research organization as required in the next 10 years and which almost certainly will not be forthcoming) would help these countries to industrialize and to make better use of their soil. Against this we should set, however, the danger of still greater pressures on national resources today *vis à vis* tomorrow; and we cannot afford to leave out of account the rapid gains in population of the areas which now seek both industrialization and foreign help. Is not the net effect of these measures, which is commonly hoped would bring about a better distribution of worldly goods, then likely to be merely that a larger proportion of income would go to poorer countries? And since population would respond to the rise of goods, effects on standards would not be favorable. We may well be poorer as a result of these measures; but the poor may not become richer. Perhaps the rapid rate of population growth in many parts of the world is the most important single cause of wasteful land use today; and not until that problem is solved, can there be much hope for improvement in the poorer countries!

We should not, furthermore, leave out of account the effects of these proposed policies on

the industrial countries. As agricultural countries move populations into cities and build factories, the old industrial countries lose ground. They lose markets; or sell at low prices, with unfavorable effects on standards; and they are frequently forced to increase their use of land for agriculture.

Great Britain's history is a case in point. Her economic difficulties are associated in no small part with increased industrialization elsewhere. In 1870, she accounted for 32 per cent of the world's manufacturing production; in 1936-38, only 9.2 per cent. In part, her losses are associated with the rapid advances in manufacturing abroad which was to be expected. Nevertheless, there can be no doubt but that there has been a deterioration of her competitive position which has brought her serious economic and political difficulties.

And New England is a case in point close at hand. Numbers employed in the manufacturing industries in the Boston area declined by 40 per cent in the 20 years preceding the outbreak of World War II; and the average loss per decade over 40 years in the number of New England's factory earners was 12.3 per cent. New England has clearly been losing ground relative to the rest of the country. New England now buys much more than she sells, the excess being financed largely through returns on past investment and new borrowings. As long as the position of the capitalist and rentier is so precarious, the position of New England will be precarious: with poor land, with large and insistent demand for food and raw materials and with a declining manufacturing (and export) industry New England's position will continue to be uncertain.

In short, the problem of land use is not merely one of better current utilization of land. It is necessary to consider the distribution of use between today and tomorrow; relative employment and output in agriculture, and industry; the relation between income and demand on the one hand, and production from land on the other; and finally the relation between population growth and land use.

The Geographic Meaning of Ecological Land Use

EDWARD A. ACKERMAN

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THE MOST significant phase of the ecological land use problem is that of cultivation agriculture, for the greater part of our food is produced on cultivated fields. As post-war events have proven, the food problem is a world problem. I therefore should like to direct attention to the character of cultivation agriculture in the world as a whole.

As in the United States, examples of both good land use and poor land use are to be found elsewhere in the world. To show that we are not hoping for the impossible in proposing widespread changes in land use, I shall commence with an example of good cultivation in the fields of one of our southern neighbors.

In February, 1946 I visited Cuba. As part of that visit one day I looked over a sugar-cane field. It was a beautiful field, with ten-foot canes so thickly set that a man could not walk through them. I was particularly interested in it because it was just the sort of land that we have had so much difficulty with in this country during the last twenty years—with a rolling surface, a heavy soil, subject to intensive rains for part of the year, and to drought for the remainder. The same type of land in our southeastern states almost without exception shows the effects of harmful erosion in one degree or another. Fields of this sort in our Southeast have little true topsoil remaining, and are constantly in need of heavy fertilization. Yet this Cuban field, which was by no means unique on the island, had a two-foot layer of black humus-enriched soil, and it showed not the slightest sign of erosion. Furthermore, it had produced heavy cane crops for thirty years without the addition of an ounce of artificial fertilizer, according to the farmer who managed it. The secret lies in the cane-harvesting practices which prevail in the area, accidental though they may be. In that same clearing we stood knee-deep in debris from cane cutting. It was composed of otherwise useless leaves, lopped from the canes as they were mown and strewn evenly over the clearing. It was a perfect mulch to protect the topsoil from eroding run-off, and an excellent raw material for adding to the organic matter in the soil. An agronomist could prescribe very little more.

That sugar-cane area is an excellent example of ecological land use. 1) It produces a high-yielding crop which furnishes a staple commodity among world foods. Many other soil-conserving crops, on the contrary, do not yield staples. 2) Near maximum production has been maintained, and can be maintained indefinitely on that field without physical deterioration of the soil. In other words, the land is stable. 3) There has been a minimum dependence upon outside sources for plant nutrients, a maximum dependence on the natural fertility-forming processes of the soil. For the future this last may be one of the most significant parts of the ecological method, as I shall try to prove later. 4) Finally, farming in the area is a relatively simple process—without elaborate preparation, understandable even to an illiterate peon.

Sugar cane, of course, cannot be grown everywhere; and few of us would wish to be nourished by it exclusively, even if it throve in Siberia or New England. Nevertheless, if the same principles of land management had been applied to all the agricultural lands of the world, there would be less talk of food problems, fewer fears

of famine, and no books on The Rape of the Earth. But, as others before me have shown very clearly, only a minority of the world's cultivated lands have been so treated. On the contrary, many show the effects of neglect, ignorance and misfortune to an alarming degree. Someday very soon millions of other farmers will have to do what the Cuban cane-farmer has done instinctively. When attempted, this will be a really revolutionary development which has many geographic implications.

By "geographic implications" I mean that the methods, resistances to establishment, and results of ecological land use will differ a great deal for the numerous regions of the world. The foreseeable effects are likely to be quite startling in some places, and entirely negligible in others. In addition the universal application of ecological land use raises some inter-regional problems which may rise to disturb politicians, economists, and plain citizens for a long time. Resettlement, education, large-scale engineering, and world-wide integration of crop-production may be involved.

There is time here to describe these manifold regional differences only in a broad and rough classification. I have chosen five natural types of agricultural land within which the possibilities of ecological land use should concern us most. They are: 1) The humid middle latitude lands in which we live (e.g. Eastern North America and Western Europe). They are interesting not only because of our selfish preoccupation with them, but because they have been the major food and raw material deficit areas of normal world trade. 2) The semi-arid to subhumid cereal-growing lands, which have supplied a share of world grain production disproportionate to their resident population (like the Great Plains). 3) The humid subtropics (Southeastern United States and China). 4) The seasonally dry tropics (wet-and-dry low latitudes) (India). 5) The rainy low latitudes (Brazil, Central Africa). The third and fourth types (humid subtropics and the seasonally dry tropics) are of interest to us as the generally most productive of the earth's agricultural areas, and the last, the fifth type, for its undeveloped potentialities. (See map, center spread, pages 78-79.)

For each of these five land types I should like to suggest the answers to three pertinent questions: (1) How seriously do the prevailing land use practices depart from the principles illustrated by the Cuban cane-farm? (2) Then: will economic necessity and cultural habits permit the institution of ecological use locally? And last: (3) what dislocations might the adoption of ecological land use cause in world food and raw material supplies?

In spite of the example with which I chose to begin this discussion, ecological land use has been best worked out for the humid middle latitude lands, particularly in western countries. A comparatively low natural susceptibility to erosion, the suitability of many sections to forage and fodder production, and the important position of animals in the farm economy all have contributed to a relatively stable land resource, a dense population notwithstanding. Paternal governments and a high rate of literacy have helped. Yet there are lands in this classification which are not yet stable. Sloping cultivated lands in midwestern United States, in southeastern Europe, and European Russia are either deteriorating or have reached a state of low productivity. They probably can be treated in ecological fashion only if there is a definite curtailment in grain acreage in the affected regions. But all of them form only a minor part of the millions of acres of intensively farmed land which fall within this class. The humid middle latitude lands are well on the road to ecological management, and there are few inherent difficulties to hinder further progress. The greatest single avenue for improvement probably lies in more widespread adoption of humus-building cultivation, and less dependence on commercial or mineral fertilizers.

But these areas, in spite of their past power for disturbing the world's peace, are far less important in feeding, clothing, and otherwise supplying the earth's inhabitants than two of the other land types. There are many more

mouths to be fed elsewhere, as the following table indicates:

GENERAL RELATIONSHIP OF THE PRINCIPAL AGRICULTURAL LAND TYPES TO THE WORLD AS A WHOLE

	Per cent of World Land Area	Per cent of Population
Humid middle latitude lands	9	25
Humid subtropics	4	25
Seasonally dry tropics	13	20
Semi-arid and sub-humid lands	18	10
Rainforest low latitudes	8	4
Other	48	16
	100	100

Furthermore, many residents of the humid middle latitudes depend heavily upon the production of other areas for food and materials. The adaptability of the other four land types to a system of productive stability is therefore of direct interest to those who live in those favored areas, as well as to the remaining three-fourths of the world's residents.

The two land types which bear a major share of the burden of providing for people are the humid subtropics and the seasonally dry tropics. India is supplied with nearly all it receives by one, Japan and China by the other. Ninety percent of the world's most important textile fibre, cotton, also comes from them; they supply a major part of the world's sugar; and they are the sole or major sources for many minor products, like tea, coffee, silk, jute, vegetable oils, and others.

True ecological land use is the exception within these areas, although some sections have physical stability. Any unlevel land here, however gentle the slope, is naturally highly susceptible to rapid water erosion when placed under cultivation. Anyone familiar with the exposed subsoil, the gullies and muddy streams of the Virginia hills or Carolina Piedmont has seen a picture which illustrates conditions in similar situations elsewhere. Men generally have not succeeded in adapting their farming and other land utilization to the exacting demands of those environments. The scenes recorded in the South by photographers of our Soil Conservation Service are repeated over and over again within these land types — in Latin America, Africa, India, and China, wherever commercial expansion or population pressure tempted men into cultivation of the susceptible lands. Although no one knows exactly, probably more than a third of the soils in these areas are a physically declining resource — destined for destruction or sterility under present management methods. There is still too much grain grown, and too many other open field crops.

For the lands of these types within regions of moderate population the transition to ecological management will not be attended by any great difficulties. It is a matter of reducing the acreage of crops like cotton and corn, having less bare land and substituting soil conserving plants. But for the enormously overloaded lands of India and China the obstacles are tremendous. There it is not simply a question of educating to new methods, or acceptance of a temporarily reduced income by farmers. It is one of producing enough food today to keep ahead of tomorrow's famine. Ecological land use cannot be practiced in China until the whole economy of the country is reorganized—reorganized to produce enough without the aid of the deteriorating lands. Even then the consumption of mineral fertilizers will always be relatively high, for the dominant rice culture is nothing more than a kind of soilless cultivation, where input (of fertilizer) must balance output (of grain).

In India there is even less hope of solution. One of the keys to the conservational situation lies in the great population of cattle, used and useless, which press so closely on the fodder supply that there is said to be comparatively little organic matter to return to the soil. Even their dung is of no use in fertilizing the soil. It is used as fuel, because pasture takes up land on which trees or scrub might grow. These millions of unneeded cattle are tolerated because of a religious tabu, as deeply rooted as the feeling of many of us about the truth of Christianity. Yet there can be no ecological land use in India until this, as well as a number of less arresting problems, is solved. How does a soil conservation advocate deal with religion? I fear that

successful prosecution can be only a very extended process, no matter what the method of attack.

The remaining two land types, the rainy low latitudes and the dry lands, are interesting in opposite ways—one for its future, and the other for its past. The dry lands have a long history of past productivity under cultivation, while the rainy tropics have an unmeasured potential.

For the dry lands experience has given brief but clear answers. Only three forms of land use fit the ecological requirements for most parts of the area, carefully managed perennial grazing lands, tree and shrub crops, and irrigated cultivation. Dry farming of annual grains and legumes should occupy a much less prominent place in land use than it now does. A very definite curtailment in the world's grain acreage would take place if ecological use were applied to these regions. In the end curtailment will have to take place, if only by the total destruction of many dry-farmed lands. Northwestern China already has Exhibit A for those interested in the end-product—a desert which once was cultivated land. But here again economic necessity will make the transition exceedingly difficult in some of the hardest-pressed areas. What will the land use manager do with the millions of people who cannot be supported immediately on the land in North China or the Mediterranean, once ecological use is instituted?

One answer might be—encourage the establishment of more cultivation in the rainy tropics. That is a possibility, for they offer some striking examples of intensive and long continued cultivation, like Java. I shall pass over the problems of sanitation and health, which are still important, but nearer solution than we thought possible a few years ago. But cultivation in the rainy tropics also must be approached with a good deal of caution nonetheless. Usable soils are often highly erodible under the heavy rains —destruction being a matter of days and weeks, rather than months and years, as elsewhere. Most important of all is the very high demands for fertilizers which characterize these lands under cultivation. The supplying of nitrate of course is no longer a problem (because of nitrogen fixation), but the provision of potash, and especially phosphate may very well be a critical consideration. Many soils in the rainy tropics have the quality of fixing phosphates—that is, even applied phosphate enters into chemical combinations in the soil which make it unavailable to growing plants. Only a very heavy application overcomes this quality.

This one item, provision of adequate potash and phosphate, should make us think twice about any conscious extension of cultivation in the unused rainy tropics. There may come a day when those two minerals are the most critical elements in the world productive organization. It certainly will come if we do not succeed in extraction of both from sea water. The known landmined supplies are quite limited; we have not yet commenced to use them in the quantity in which they will be demanded shortly; and we have not yet succeeded operating our cultivation with a closed potash or phosphate cycle. A world-planned ecological land utilization therefore will give careful attention to the efficient use of these minerals.

If we ever come to the day when, through United Nations or other means, we attempt to plan land utilization on a world-wide basis, we shall face some problems which will tax the initiative, energy, and ingenuity of the best among us. Unfortunately, accidental conformity to ecological principles, like the Cuban cane farm, have been all too infrequent in the history of world cultivation. Only planned utilization can bring about universal conformity. The bureau, or legislative assembly, or individual charged with the responsibility of putting the principles into widespread practice will have a task of infinite complexity. It involves such things as the resettlement of tens of millions of people; the education of hundreds of millions; the neutralizing of religious beliefs; the establishment of whole modern transportation systems; a painstaking worldwide search for deposits of fertilizer minerals; and careful planning of substitute production for the lands withdrawn from use,

(*Continued on page* 76)

Is Special Equipment Needed for Stubble Mulch Farming?

L. G. SAMSEL

MR. SAMSEL is supervisor of the Educational Division of the J. I. Case Company, Racine, Wisconsin. This article presents his experiences with equipment that may be used in stubble mulch farming.

DURING THE past few years it has been my privilege to observe stubble mulch farming procedures in several western states and one Canadian Province. I have also studied rather carefully the results of experiment station tests and have talked to numerous government project supervisors and farmers on this subject.

From the standpoint of soil and moisture conservation and maintenance of yields, I am convinced that stubble mulch farming has a place in Great Plains agriculture and possibly that of other regions. I'm not so sure that much of the specialized equipment now being tried will prove more desirable for stubble mluch or crop residue farming than the more ordinary machines now found in common use and which are readily adapted to the various operations being advocated.

Most of us in speaking of stubble mulch farming think of weed control, seedbed preparation, seeding, row crop planting and cultivating —not just tilling the soil. So, a number of pieces of equipment are to be considered. Let's first consider machines for tillage.

Most everyone is acquainted with a moldboard plow. I had heard from Soil Conservation Service men that the plow could readily be converted to a mulch tillage unit. Last summer with the help of a Soil Conservation District Commissioner in Montana, a 4-bottom plow was operated in heavy stubble residue. The only adaptation required was removal of the mold boards and bracing of the shares against the landside. The following was observed:

The plow could be operated at normal plowing depths if desired. The pitch of the shares stirred the soil more than the flat blades of many specialized tillage tools. A good cover of standing residue was left on the surface. The stirring or lifting action of the shares appeared to effect unusually good weed kill, especially at the shallower depths. The draft was considerably less without the moldboards. In fact, our tractor could have readily handled eight bottoms.

It has been my privilege to see the performance of a number of specialized blade tools, some tractor mounted and some pull behind. Most of these machines do their work well, but I see little advantage in their use over an adapted moldboard plow, especially where normal plow depth tillage may be required.

Blade tools may have some advantages in keeping down weeds and maintaining the stubble covering where repeated operations are required between harvest and seeding of the next crop, as in summer fallowing. Operated at shallow depths, exceptionally wide units can be drawn at fast tractor speeds for quick coverage of large fields. After the land has once been tilled, however, with whatever equipment might be available, it is doubtful if a better stubble much summer fallowing machine can be found than the rod weeder, except in stony soils.

The rod weeder proved its worth years ago in the summer fallow areas of the Northwest. It drags weed roots toward the surface and maintains the crop residue covering. I'm sorry it was necessary to use that phrase, "except in stony soils." Stony soils present problems in the operation of any kind of equipment.

The one-way disk plow or cylinder plow was born near that section of the country once referred to as the "Dust Bowl." In the rose pinning that accompanied and followed those dusty years, the one-way was not slighted. Yet, you

A conventional one-way disk plow operating in heavy stubble. A slower working speed leaves more stubble on the surface.

can find fields that have been worked year after year with the one-way without loss of yield and without appreciable soil blowing. Like any other machine, the one-way requires a certain amount of judgment in its use. Then, too, there are different types of one-way plows.

The modern one-way with large wide spaced disks does not pulverize most soils any more than a moldboard plow or a blade or sweep tiller. The one-way does mix a portion of the surface residue with the soil. In heavy stubble, a partial covering of the residue is not objectionable. Repeated operations with the one-way will, of course, eventually bury stubble residues. The conventional field cultivator (duck foot) or rod weeder should probably be used for stubble mulch summer fallowing after first plowing with the one-way.

Up in Saskatchewan, they found that the use of shallow cupped disks and reduced traveling speeds with the one-way disk plows materially helped in preserving stubble cover.

Another adaptable stubble mulch tillage tool found in use in many western farms is the lister planter. Merely remove the lister bottoms and attach sweeps or blades of suitable cutting width. Many such attachable blades are on the market or soon will be.

Bare plowed fallow is usually packed or firmed in some manner before seeding or row planting. Common tools used are the disk or spike harrow, or both. Stubble mulch tilled fields often need some sort of firming too, in final seed bed preparation. Obviously the disk harrow or spike tooth won't do. They pulverize wind resisting clods and bunch or chop up the residue.

Quite a number of specialized packing tools for stubble mulch have been devised. Some are large diameter "V" shaped wheels spaced on a common axle shaft. Others are designed to simulate animal hoofs. Soil conservationists have discovered an ideal packing tool, however, in a machine long known to farmers of the East and Midwest—*the rotary hoe*. To make an ideal "treader" or stubble mulch packer, you merely

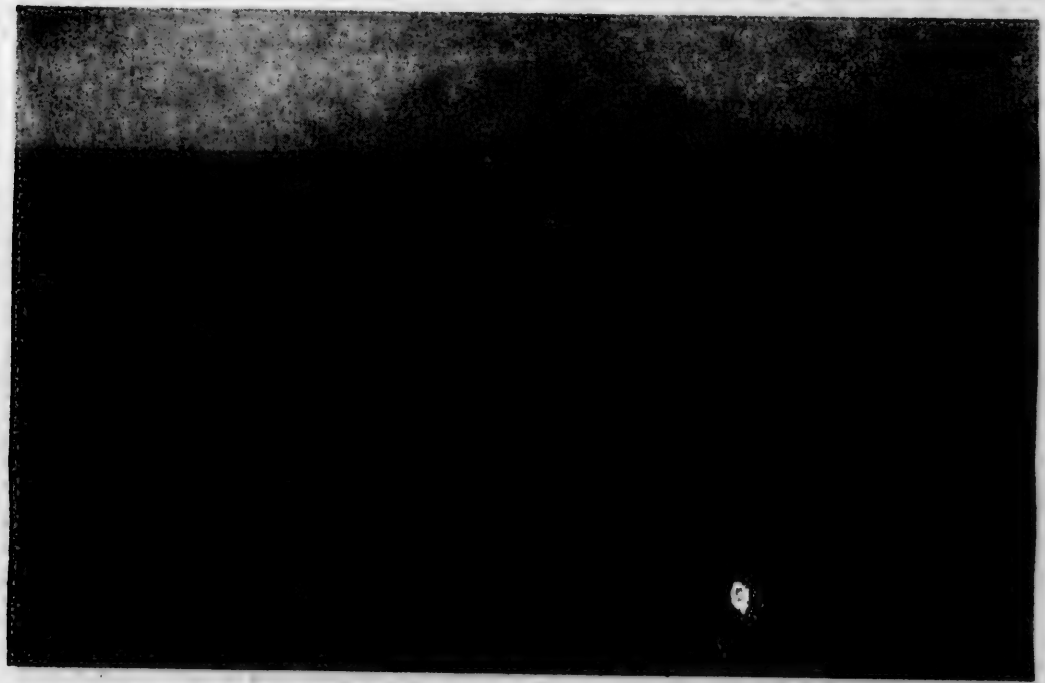
pull the rotary hoe backwards. The hoe wheel fingers press through the trash into the soil with a positive firming action. Weights can be added to the hoe units if needed. Rotary hoe sections can be pulled behind tillage machines or seeders or used separately if desired.

Some attempts have been made to build special stubble mulch drills or seeders, some with duck foot openers, some with a combination flat disk and moldboard type of opener. The ability of these machines to do the work intended is not questioned. Whether such specialized seeders are needed is questioned.

In summer fallow (alternate year cropping) areas, especially spring wheat regions, the stubble is pretty well broken up by seeding time. Standard disk drills will usually effectively penetrate the mulch without clogging. Most standard drills can be fitted with semi-furrow openers spaced twelve or more inches apart, to allow ample clearance for trash. These openers spread the seed in four-inch rows. This means that the space between rows need be no more than eight inches—an important consideration in controlling weed growth between rows.

In Western Canada a favorite seeding machine for mulch covered fields is the one-way disk plow with seeding attachment. The large disks cut positively through the surface residue. The seed can be guided through ribbon tubes to the disk marker or scattered broadcast just back of the disks for thick stands to discourage weed growth. The use of a "treader" behind the one-way firms the soil for better germination of the seed.

Some have thought especially built row crop planters to be needed for stubble much farming and have spent considerable time in the attempted design of specialized machines. (I'm speaking of surface planters. Lister planters have always operated successfully in trashy ground.) This spring a group of us tried out



This is a 24-6 plain high wheel drill converted to a 12-12 semi-deep furrow drill. This converted machine has ample clearance for the stubble residue to pass between the openers.

a standard type row planter in a residue covered field. The only change from regular equipment was the use of single disk furrow openers. Planter manufacturers have had such openers available as optional equipment with runner planters for many years.

The sharp disk openers cut through the stubble residue without difficulty. The unevenness of the residue, however, made it impossible to plant all the corn at an even depth and in firm, moist soil. We reasoned that this could be accomplished by pushing the residue to one side ahead of the planter opener.

Our tractor was an all purpose model with a mounted row cultivator available. We removed all the cultivator shovels and standard and installed on each row unit a set of large 16-inch disk hillers. The disks were set just deeply enough to scrape away the stubble where each planter runner was to operate. Any planter runner would then operate in the shallow furrow provided. And so we surface planted corn in stubble residue using only equipment which the land owner was likely to have or could readily obtain from a manufacturer.

We also cultivated corn planted in stubble residue using a standard tractor mounted row-crop cultivator. For first cultivation, small disk hillers operating next to the crop row were set to "throw out." Behind the disks at a distance ample to clear the stubble residue, 12-inch sweeps destroyed weeds and moved as much soil to the row as the size of the plants would permit. Broad sweeps on the rear tool bar of the tractor worked the center area between crop rows. For later cultivations, the disk hillers were reversed to "throw in" and move as much soil to the crop row as needed to cover weeds. None of the equipment was new or especially made for stubble mulch farming.

These comments are made, not to decry the efforts of inventive minds, nor belittle the need for new machines and attachments. It is suggested, however, that we first investigate, try out, and adapt, if possible, equipment already available. Let's make capital of what has gone before. In doing so, we may save considerable time, effort, materials, and reduce the cash investment needed for equipment to carry on new farming practices.

The Biology of Soil Structure

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SOIL STRUCTURE has an important influence on soil erosion, water intake, and crop growth. Although a dispersed or compact soil has a low infiltration rate, a stable, granulated soil will permit rapid water intake, drainage, aeration, and beneficial microbial activity. Crops respond to fertilizers applied to aerated, drained and granulated soils. Among the most effective aids to good management in maintaining or improving granulation are microorganisms and their decomposition products.

Structure of the Soil

Growing plants and microorganisms constitute the living phase of the soil. In it are living and non-living bacteria, viruses, phages, fungi, algae, protozoa, earthworms, nematodes, and insects. These organisms have numerous enzymatic systems which are capable of producing available nutrients for the growing plants by breaking down some of the many organic compounds in the soil.

Physically, a good soil is made up of about five per cent organic and 95 per cent inorganic materials by weight. The influence that the small amount of organic matter in most soils exerts is out of proportion to its weight and is more directly related to the volume it occupies. This organic fraction of the soil is made up of plant and animal remains in all stages of decomposition. Chemically it is composed of sugars, starches, celluloses, proteins, lignins, vitamins, pigments, fats, oils, and myriads of compounds in all sorts of configurations and combinations.

The mineral portion of the soil is made up of a sand, silt, and clay mixture in different combinations to make specifically a clay, silt loam, or soil of some other texture. The chemical elements of the inorganic fraction are composed largely of oxides, silicates, and phosphates, of calcium, potassium, magnesium, etc., and the number of compounds ranges into the hundreds.

Usually the sand, silt, and clay in the soil do not remain as individual particles but become organized into groups, which are called aggregates or structural units. These structural units are formed largely by physical forces such as wetting and drying or freezing and thawing. They may be of various sizes and shapes and in the same soil may follow a definite pattern. They are united by chemical, physical, and biological forces. They are held together specifically by materials such as silica, clays, iron oxides, and constituents of organic matter. The latter include plant roots, soil organisms of various types, and organic cements of resins, gums, waxes, fats, and lignins (1, 5, 7).

Not all organic matter will stabilize the soil. For example, some organic constituents, such as sugars, do not stabilize soil granules. The sugar can be transformed into microbial tissue and decomposition products which are highly effective in soil stabilization. Only the fats, waxes, lignins, oils, proteins, resins, certain decomposition products of bacteria, and fungal filaments have a direct stabilizing effect (7), as shown in Table 1 and Figure 1. These organic substances stabilize the platy, or granular units formed by processes of wetting or drying and freezing or thawing.

TABLE 1.—THE EFFECT OF SOME ORGANIC COMPOUNDS ON SOIL STRUCTURE STABILITY.

Substances added	Concentration 0.5%	1.0%	2.0%
	drops per 0.1 gm. soil*		
None		4.5	
Waxes and fats	4.7	13.4	53.5
Carbohydrates	4.5	4.3	4.2
Hemicelluloses	4.4	4.2	4.5
Lignins	9.1	17.0	24.7
Cellulose	4.2	4.6	4.3

*Number of water drops falling 30 cm. required to wash an 0.1-gm. soil lump through a 1-mm. mesh screen. The organic compounds were applied to lumps of Peorian loess (devoid of organic substances) to equal concentrations of 0.5, 1.0, and 2.0 per cent.

Particles of organic matter such as cellulose are without direct effect on soil structure, but can be transformed into effective stabilizing agents by soil organisms. Some decomposition products are more effective than others. In many instances they are non-wetting agents and stabilize the soil in this way.

Some of these organic compounds such as lignins, resins, and oils are proving effective in solving specific soil stabilization problems (6). Vigorous research will continue to find and develop new substances for use under diverse conditions.

INFLUENCE OF STRUCTURE ON ORGANISMS

Moisture.—Soil microorganisms need available moisture to help them hasten the decay of residues and in producing available nutrients from soil organic matter for plant growth. Their requirements differ and vary over a wide range. Some, particularly fungi, may carry on the decomposition process at a low moisture content or humidity. All need a soil structure that is permeable to air and water, that holds sufficient water for plant and microbial growth, and permits the excess to drain away. A flooded soil will create conditions favorable for the growth of anaerobic organisms (12). These organisms take oxygen away from nitrates, sulphates, and other essential oxygenated compounds.

Soil structure may be improved by decaying organic matter which will increase water infiltration. At an experimental orchard of the University of California Citrus Experiment Station, Riverside, California, rates of infiltration of irrigation water were found to vary widely according to soil treatment (9). Incorporation of organic matter, either as a cover crop or as manure, greatly increased the rate of water infiltration over the untreated. The increase in the infiltration rate was related to the amount of organic matter used.

Microbial Activity.—Since organisms survive under a range of conditions, microorganisms can live under some variations in soil structure. However, all individual microbial processes are responsive to soil structure changes. Various biological processes such as nitrification, azofication, nitrogen fixation, ammonification, and production of available phosphorus and sulfur are influenced by soil conditions. Biological processes should go on in the soil at a rate sufficient to supply nutrients for crop needs, conserve as much organic matter as possible, and maintain a desirable structure.

Organic Matter Conservation.—In all cultivated or farmed soils, microbial activity has been speeded up so that the soil organic matter disappears at a more rapid rate than it accumulates. The addition of fresh organic matter does not keep pace with the loss by decomposition. The increased microbial activity which liberates nutrients and causes plants to grow better also hastens the deterioration of the soil structure by organic matter loss. A soil condition permitting slow growth of microorganisms and a low rate of oxidation of the soil organic matter conserves fertility, although the low nutrient development reduces crop growth.

Microbial Environment.—In the soil, organisms may be grouped from a nutritional and environmental standpoint—such as those that require atmospheric oxygen, certain temperature condition, or specific types of food.

Some groups of microorganisms require free oxygen; others need only combined oxygen. Thus soil aeration plays an important role in their activities. Nitrification, for example, is an aerobic process. Denitrification is an anaerobic process. In wet and puddled soils nitrates may be re-

FIGURE 1

Soil structure developed by fungi. Left, untreated Peorian loess. Right, Peorian loess in which the growth of fungi had been greatly stimulated.

duced and lost as gaseous nitrogen. Soils in good tilth with adequate fertility reserves may produce nitrates abundantly. The degree of soil granulation and the arrangement and compaction of the granules play an important role in soil aeration, water infiltration, and drainage.

When soil conditions are favorable, microorganisms take oxygen from the air. When conditions become unfavorable, through poor soil structure or excessive moisture, the organisms use the combined oxygen of the nitrates, sulphates, or other compounds. This microbial activity may render the soil unfavorable for plant growth.

It is generally true that some types of microbial activity, beneficial, neutral, or harmful to crop growth, will take place regardless of the soil condition. It is necessary, therefore, to maintain those soil conditions that will stimulate beneficial microbial activities. Hoffer (4) showed that with conditions unfavorable to soil structure corn did not respond to either light or heavy fertilizer applications in the field. With good soil structure, increases in yields up to 85 bushels per acre were obtained. He believed that unfavorable biological activity resulted in a reduced soil condition. A soil structure promoting beneficial microbial activity can be maintained by proper tillage, drainage, residue management, and fertilization.

Toxic Soil Conditions.—Tillage of a wet soil may cause puddling, with the loss of structure. Conditions that are more favorable for anaerobic than for aerobic bacteria soon develop. In a wet, anaerobic soil response to fertilizers may be slight. Drainage, loosening up of the soil, or allowing it to dry out will reduce the growth of anaerobes and increase the aerobes. Under aerobic conditions the crop will respond to fertilizers.

Microorganisms produce substances toxic to each other. For instance, penicillin is produced by fungi. These toxic substances may be readily destroyed by microorganisms in aerated soil. Under other soil conditions, such as with poor drainage, excessive moisture, or anaerobic conditions, they may persist. Crop growth may be retarded. The maintenance of a favorable

physical condition is insurance that those bacteria will predominate which perform many beneficial functions in the soil.

Wetting and Drying.—Wetting and drying of the soil greatly increases microbial activity. Therefore, soil structure as it influences the rapidity of wetting or drying influences the rate of microbial activity.

Drying of the soil causes the soil flora to change to a spore stage or into an inactive form. As a result, microbial activity drops to a low level. When the soil is rewet, with other conditions favorable, the organisms go into a vegetative stage. Microbial activity is resumed at a higher level. The organisms multiply at a rapid rate, until food exhaustion or some other factor limits their activities. The increased microbial activity results in the liberation of carbon dioxide and mineral constituents, such as nitrates, phosphates, and potassium salts.

INFLUENCE OF STRUCTURE ON YIELDS

Breazeale and McGeorge (2) showed that puddling the soil reduced nitrification. This in turn decreased the growth of tomato plants. When grown in soil with a poor structure, they were stunted, yellow, and abnormal in appearance, indicating a low nitrification rate. Tomato plants grown in soil with good structure were normal in vigor. Nitrification supplied ample available nitrogen. Since nitrification is a function of an aerobic flora, their activity should be encouraged in the soil.

Myers and Myers (8) concluded that the favorable effects of legumes upon subsequent small grain yields may be largely because of their effect on soil structure rather than their influence on the available nitrogen of the soil.

At the end of a 6-year period there was a straight-line relationship between soil aggregation and onion yields, at the Rhode Island Experiment Station, as shown by Ryansiewicz (11).

In Ohio (3) on non-fertilized plots the average yield of sugar beets was 6.9 tons per acre for a 6-year period. The application of 300 pounds per acre of 2-12-6 in the row showed no increase from fertilization. Other fertilizer applications produced no significant increase in yields. When this land was fertilized with manure, which improved the soil structure and supplied plant food, highly significant increases in yield were obtained.

MAINTAINING SOIL STRUCTURE

A biologist's viewpoint of soil structure may be different from the viewpoint of the engineer, chemist, or soil physicist. Ultimately, the final objective of all, through tillage, or by agronomic, chemical, or physical treatment of the soil, is to obtain the best crop growth by minimum effort —with good yields, of the proper vitamin, mineral, protein, and carbohydrate content.

Organic matter is not indispensable to soil structure. However, it does aid in structure maintenance under most conditions. It increases infiltration and aeration, and improves the general soil conditions. A loessial subsoil devoid of organic matter, with proper fertilization, will grow crops. But it needs some tillage to give adequate aeration for essential microbial activity and plant growth. It will erode and gully rapidly.

Microorganisms and their decomposition products stabilize soil structure. They improve soil tilth. They develop a physical and chemical condition of the soil that favors beneficial biological action.

Productive soils with a good structure can be maintained by certain cropping and management practices, as shown in Table 2 (10). For example, if manures and crop residues are utilized to the fullest extent, the conservation of soil and water, nutrients in residues, and organic matter will be more easily accomplished.

Continuous cropping of the land with corn will cause a rapid loss of soil aggregation. How-

TABLE 2.—SOIL AGGREGATION WITH DIFFERENT CROPPING SYSTEMS (after E. W. Russell).

Cropping Treatment	% aggregation greater than 0.25 mm.
3 years cotton	9
3 years clover	35
6 years lucerne	30

ever, certain crops such as grass will maintain or improve the soil structure (Figure 2). The liberal use of manure and crop residues will help a great deal to maintain the soil in a good physical condition.

Tillage of the land at proper moisture content is desirable to keep from destroying the present structure. Tillage of a wet soil will destroy the granules and many of the beneficial effects obtained by other management methods.

There are certain chemical compounds that can be applied to small areas for stabilizing the soil. Lignins, resins, and other substances have been used successfully on local areas for stabilizing the soil and increasing water intake. At the present time most of these substances have a limited use.

SUMMARY

Organisms and their metabolic products are active in the formation and stabilization of soil structure, although they play a greater role in stabilization than in formation. A good soil structure is essential for the smooth integration and performance of the multi-groups of organisms in the soil. The beneficial organisms decay plant and animal residues, liberate plant nutrients, and produce soil-structure-stabilizing substances. A deterioration of soil structure results in suppressing the activities of the beneficial groups and promoting the growth of microbial groups that render nutrients unavailable. An unfavorable plant root medium soon develops under anaerobic conditions.

Soil structure affects plant growth in numerous ways. For example, it increases water intake and drainage. It has direct effect on plant growth, such as root penetration, aeration, or anchorage. It influences biological activity such as nitrogen fixation, nitrification, or organic

(*Continued on page* 100)

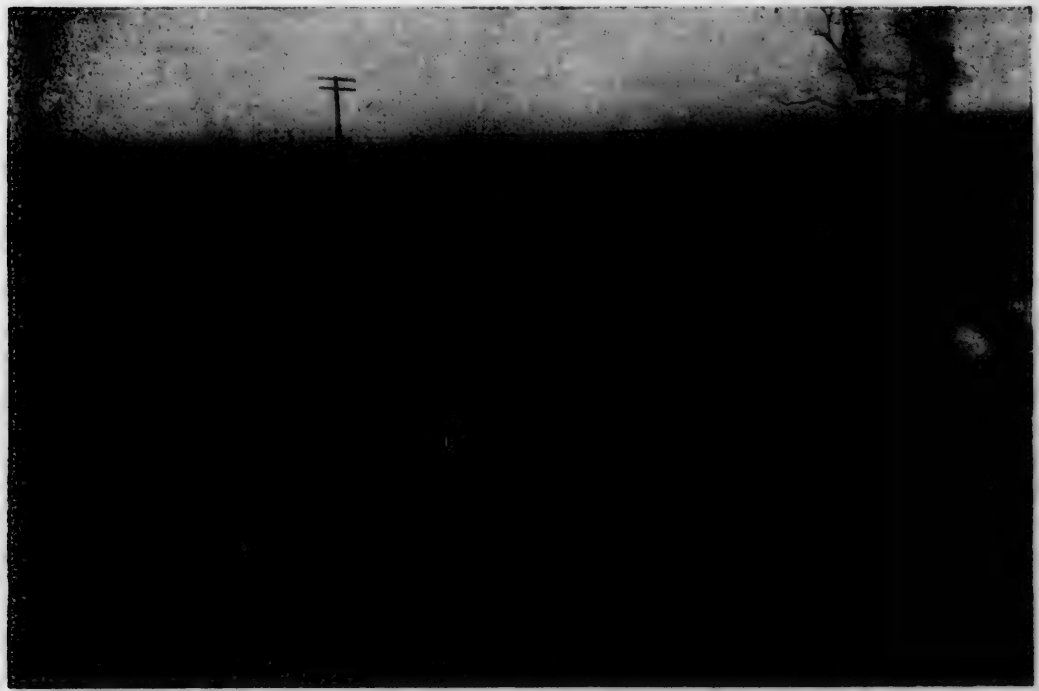


Figure 2. Land in bromegrass will increase microbial activity and improve soil granulation. However, much of this granulation will disappear in a few years under cultivation.

ECOLOGICAL LAND USE

(*Continued from page 66*)

like the dry-farming grain areas. It is so big, so intricate a task that I doubt its effective solution as a whole by the individual sovereign governments now in existence. Their view is generally too nearsighted.

While I did not begin this discussion with any idea of making it a plea for world government, I shall end it that way. Ecological land use could go a long way toward solving political problems, by providing assurance for a period, at least, of enough food, clothing, fuel and shelter for everyone. Ecological land use therefore seems to me a fundamental thing, worthy of a place on the long-term program of any international organization.

DISCUSSION

Most of the discussion was occupied with an elaboration of the details of the speakers' theses. In the give and take with members of the audience two points were made which seemed worthy of emphasis.

Dr. Leonard Carmichael remarked that not enough credit had been given to the activities of the National Resources Planning Board in its attempts to solve the problems raised by the speakers.

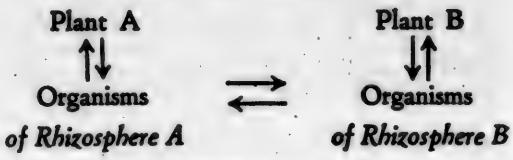
Dr. Karl Sax emphasized the various sorts of checks which operate to control the growth rates of populations. "Malthus maintained that population could be controlled by either positive checks (war, famine, and disease) or by preventive checks (control of the birth rate). The United States has averted excessive population pressure partly by greater production, but primarily by the adoption of the Malthusian preventive checks. Without preventive checks there can be no hope of a decent life in any country."

CONCLUSION: By Dr. P. R. Gast, Chairman

Dr. Graham has given us an excellent description of the complicated interrelationships which exist when we attempt to manipulate that part of the biological community which appears above ground. Because of the time limit we imposed on him, he was not able to discuss an equally complex society of plants and animals which live in the upper inches of the earth's surface. Since it is possible that we shall wish in a later symposium to elaborate other aspects of the problem of land use in more detail, it may at this time be of interest merely to suggest the content of a discussion which we should have liked to include this evening, had time permitted.

The subject, the soil biocenose, is indeed not unfamiliar. There is a growing group of enthusiasts in this country who are raising the question as to whether or not there is too much use of mineral fertilizers and a grievous lack of attention to the conservation of the organic content of the soil. For my own part, I agree with Dr. Ackerman that conservation of the humus is exceedingly important—the agitation is not all smoke and no flame.

Coming as I do from a study of the forest soils, I am convinced that the nature and amount of organic matter in the soil determine the kind of organisms that inhabit it. I know that the biotic activity in the soil is of exceedingly great importance in the maintenance of a healthy forest community. I believe that these organisms are the links which bind together the community of plants not only on forest soils but also on all untilled soils. Virtanen has shown that even in tilled soils there are "associate influences" between different species of plants. We may visualize the reaction thus: Consider plant A of one species and plant B of another. With plant A are the organisms in its rhizosphere and with B, the organisms in its rhizosphere. Rhizosphere, as its etymology implies, is the "sphere of influence" of the root. Connecting plants A and B, we have the mutualistic effects between the groups of organisms—



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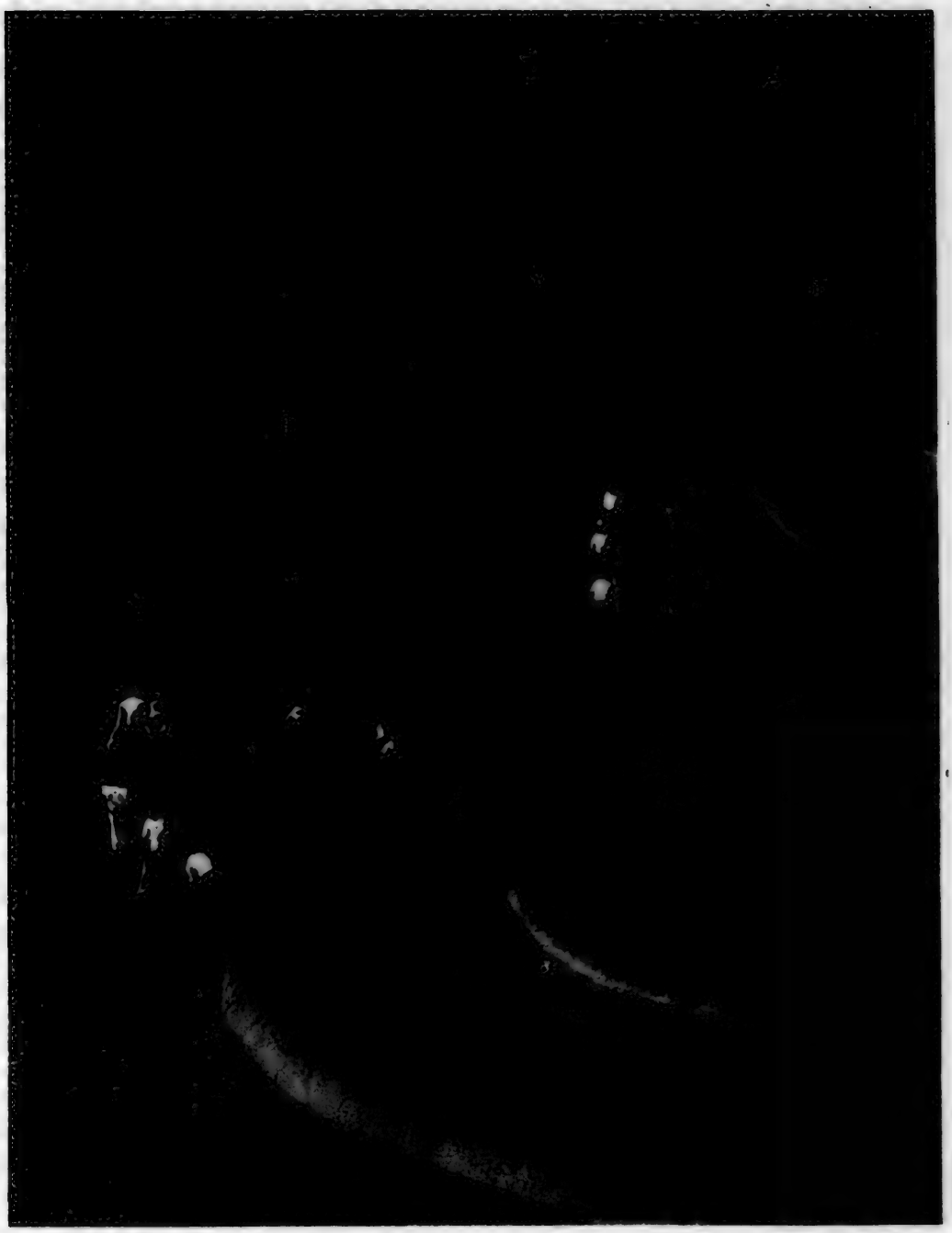
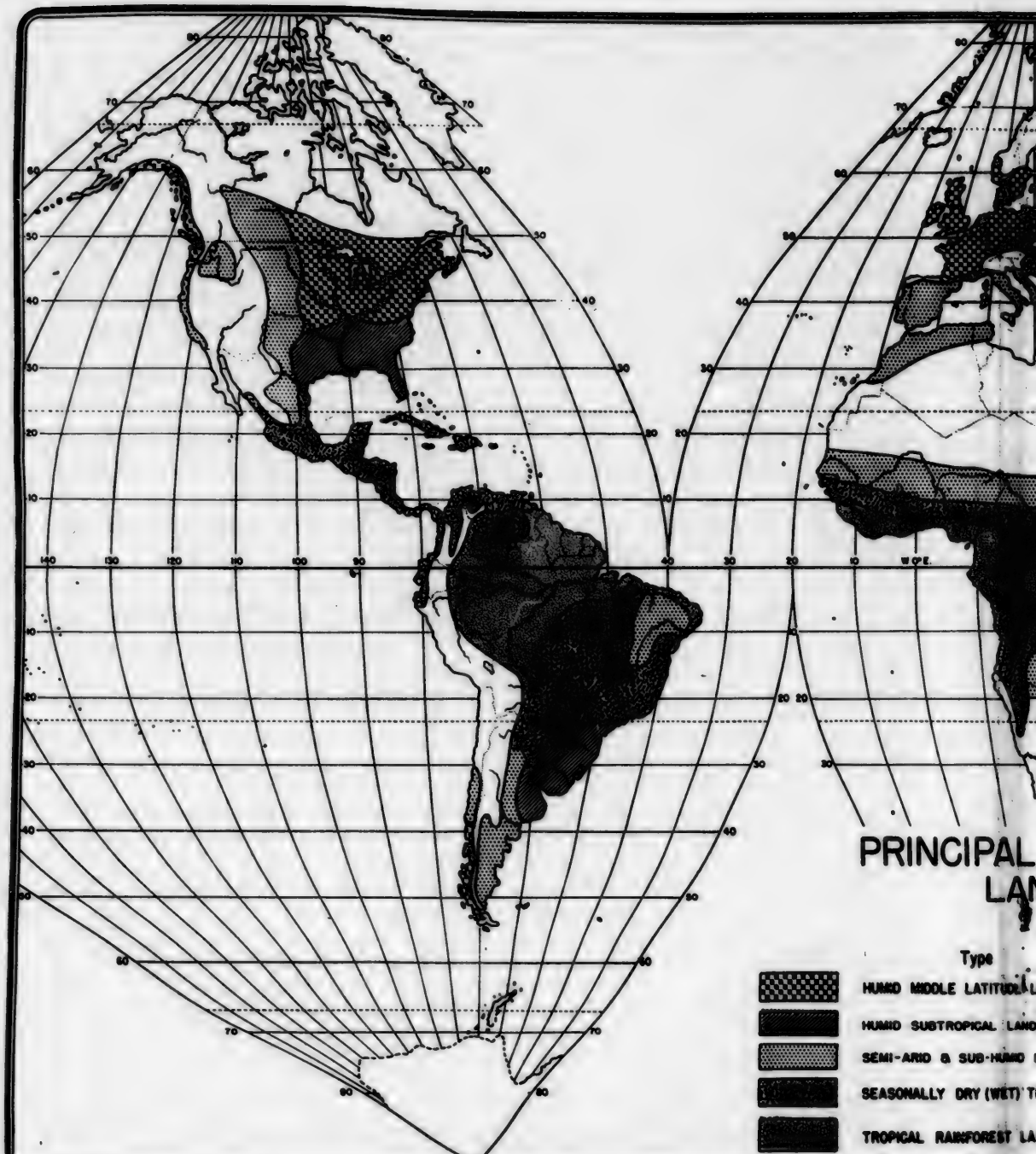
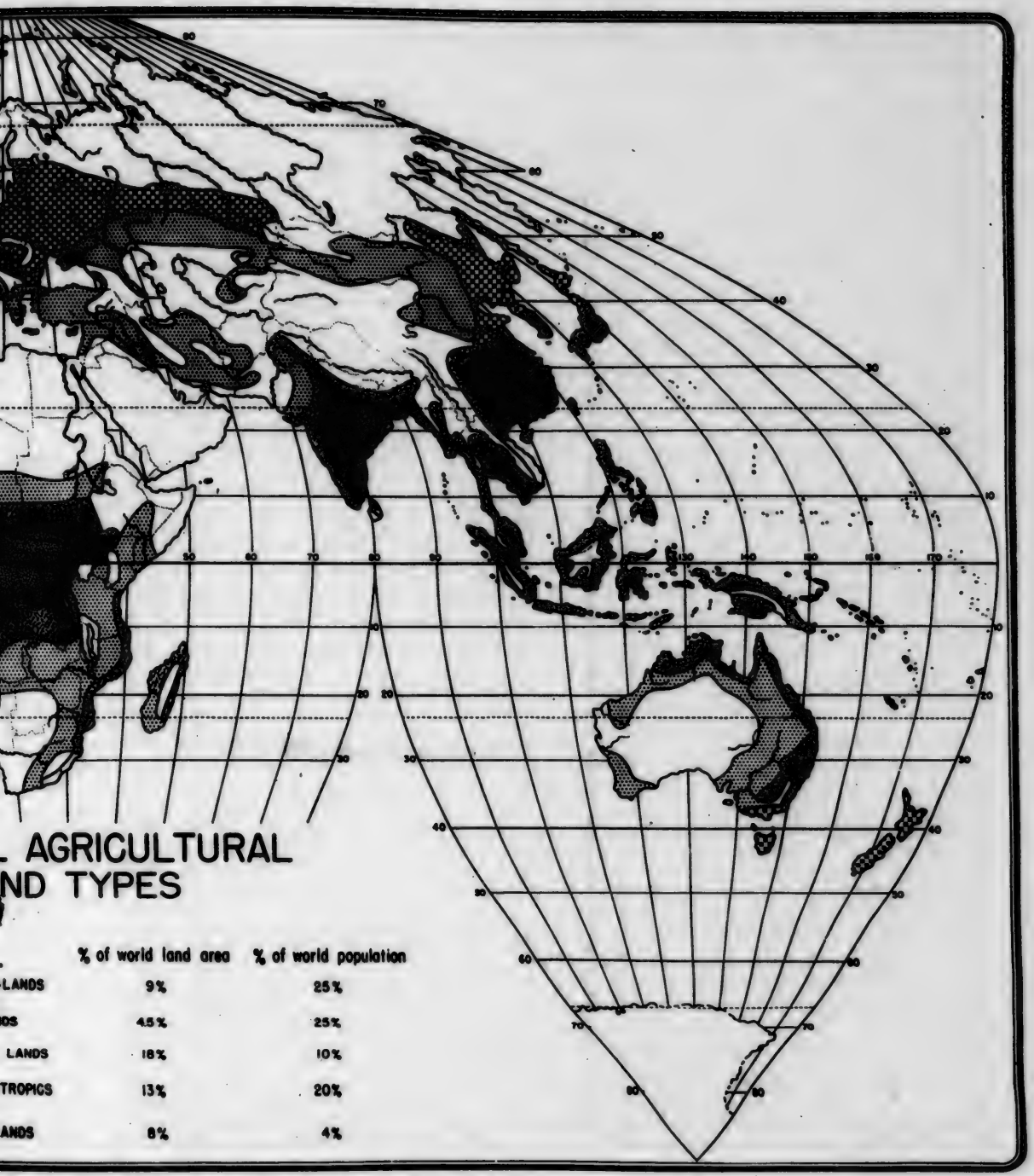


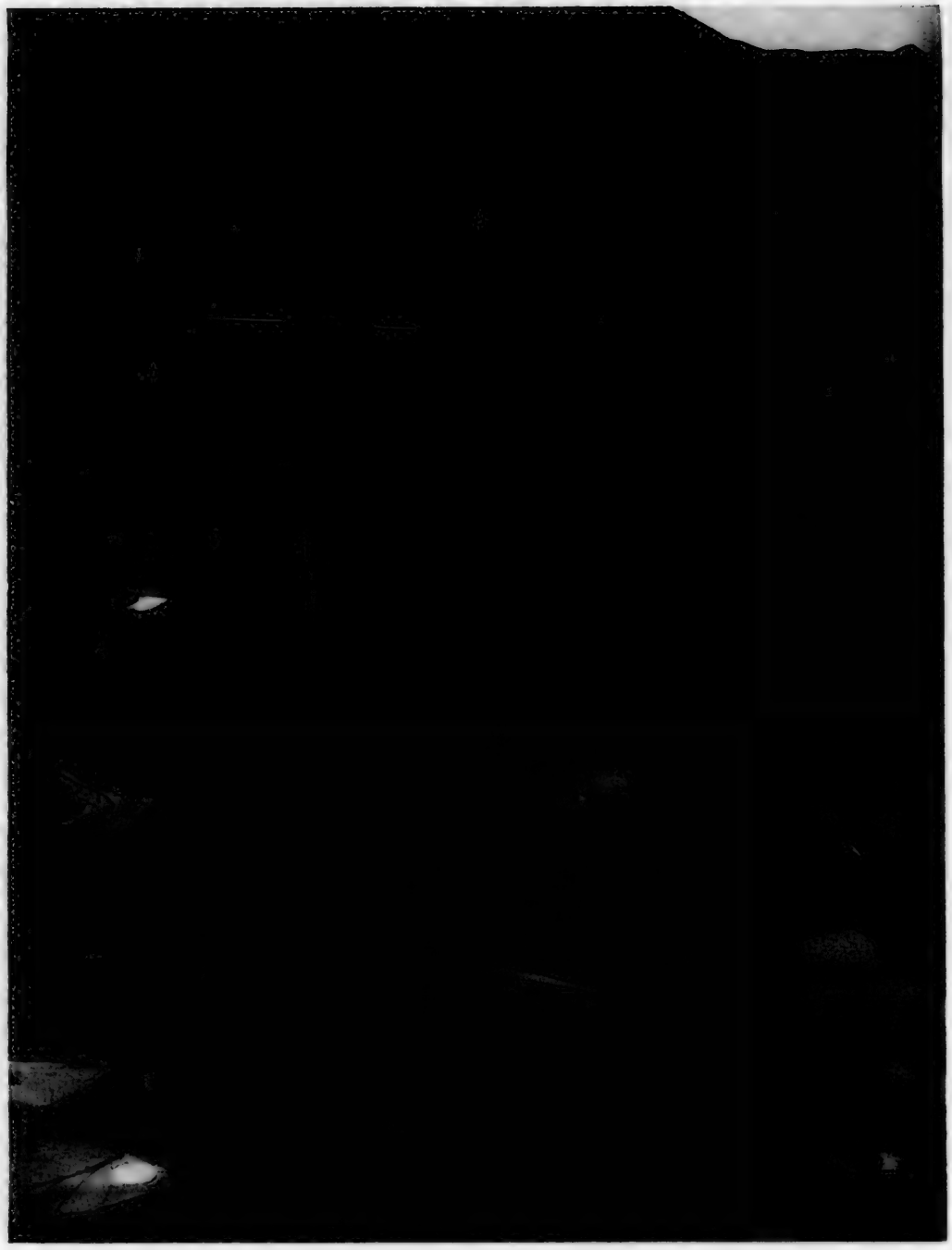
In the New World, modern bench terraces are being tried on tropical slopes near Las Ochenta, Puerto Rico. Planting ridges are being made by hand to provide drainage. The photograph, by Robert L. Davis, is from the Soil Conservation Service.



Distribution of natural types of agricultural land (
of Ecological Land Use. Journal of Soil



(Ackerman, Edward A. The Geographic Meaning
and Water Conservation, 1:63-76, 1946).



Old world care of the land has shaped an amazing pattern of ancient fields bench-terraced on the slopes of a Lebanon valley. Dr. W. C. Lowdermilk, Assistant Chief of the Soil Conservation Service, was the photographer.

The Real Values of Soil Organic Matter

FIRMAN E. BEAR

DR. FIRMAN E. BEAR, one of the Nation's outstanding soil scientists, is Chairman, Department of Soils, College of Agriculture, Rutgers University, New Brunswick, New Jersey. He is editor of Soil Science and a past president of the Soil Science Society of America.

MYSTICISM is the mother of many of the popular concepts about soils. She holds a high place in the loyalties of those who find it expedient to worship at her shrine. An international cult of her followers is now cluttering up the literature with a mixture of facts and fancies about organic matter. These are so cleverly interwoven as to make it difficult to know where one leaves off and the other begins.

Liebig explored this subject a century ago and formulated a new concept on plant nutrition. His predecessors had contended that organic matter was the food of plants. Liebig said that: "The crops on a field diminish or increase in exact proportion to the diminution or increase of the *mineral* substances conveyed to it in manure."

Soil-less Culture Now Practiced

The validity of this concept has been verified in many plant-physiology greenhouses. Perfect plants are being grown in nutrient solutions in the complete absence of organic matter. Soil-less plant culture is now being practiced on a large field scale. It consists in dissolving the necessary *mineral* salts in water and allowing this water to flow through beds of gravel, sand, or cinders that are used to provide standing room. Plants produced in this manner are equal in size and fruitfulness to those grown in soil. It seems safe to predict that any lack of nutritional quality that may be found in normal plants that are grown without soil can be remedied by the addition of some mineral element to the nutrient solution.

Fertile soils contain a great variety of mineral elements. Some of these are of value to plants and animals, some to plants only, and some only to animals. Iodine and cobalt are outstanding examples of those that appear to be of more importance to animals than to plants. A remedy for any deficiency of such elements is found in feeding their *mineral* salts directly to the animals concerned.

Plant's Purpose Is to Reproduce

If a plant had a brain, that brain would have no concern whatever with the needs of animals. Crops that have enjoyed luxurious growth often afford very poor nourishment for animals. The difficulty may lie in poisonous alkaloids that were produced within the plant. It may be the result of toxic mineral elements that were accumulated by the plant. It may be due to a lack of baance in the organic or mineral makeup of the plant. Or, as previously indicated, it may arise from a deficiency of some element that is required by the consuming animal and not by the plant itself.

The composition of a given species of plant is far from constant. It varies between a wide range of values for each constituent, whether organic or mineral. For example, the potassium content of experimental alfalfa fell from over 3 per cent to less than 1 per cent with successive harvests (table 1) while its content of calcium and magnesium was increasing by an equivalent amount.

Consideration of the mineral composition of plants has led us for afield from soil organic matter, but not without purpose. If organic matter is not the food of plants, what is its

TABLE 1

Milliequivalents Ca, Mg, and K per 100 Grams Dry Weight First and Eighth Crops Alfalfa Grown on 6 Soils

Soil Series	First Crop Ca	Mg	K	Sum	Eighth Crop Ca	Mg	K	Sum
Collington	90	31	61	181	111	37	30	178
Washington	94	29	52	175	141	36	19	196
Penn	126	19	53	198	134	23	31	188
Lansdale	93	21	59	173	123	26	30	179
Dover	81	34	60	175	115	57	19	191
Dutchess	95	25	51	171	117	39	29	185

value in the soil? The point to be remembered is that one can grow perfect plants without either soil or organic matter. But this does not argue against encouraging greater attention to both the soil and its content of organic matter in farming practice. What we are aiming at is to separate facts from fancies so that we can proceed intelligently to a consideration of the many perplexing problems in soil conservation.

VALUES OF ORGANIC MATTER

It is now generally agreed that organic matter, either by its decomposition or merely as a result of its presence in the soil, has value because:

(1) It serves as food for various types of desirable soil microorganisms.

(2) It supplies essential elements for re-use by succeeding plants.

(3) It aids in improving the physical qualities of soils.

(4) Its presence as living or dead material on or in the soil aids in the control of erosion by wind and water.

(5) In mulch form it increases water intake, reduces water loss, lowers soil temperature.

Many other more or less obscure values may be assigned to organic matter. The possibility exists that plant-stimulating hormones are released during its decay. Farmers are impressed that it has crop-insurance value, both in getting young seedlings through the soil crust and in protecting plants against various other adversities. At this point the scientist sees "through a glass darkly" but tremendous possibilities present themselves to the untrammeled imagination of the charlatan.

FERTILIZERS MAINTAIN ORGANIC MATTER

My own interest in soil organic matter goes back 40 years. For some time a controversy had been under way on the relative merits of manure and chemical fertilizers. Finally Charles E. Thorne, Director of the Ohio Agricultural Experiment Station, pointed to the 74-year average yield of 34.5 bushels of wheat per acre produced on a plot on the Rothamsted Experimental Farm in England. That plot had never received anything but chemical fertilizers. That is the highest longtime authenticated yield of wheat known. A plot alongside that had been *manured* every year lacked 1 bushel per acre of reaching that yield.

My first contribution to the subject of soil organic matter was published, in 1916 as a bulletin from the West Virginia Agricultural Experiment Station. It dealt with the residual effects of fertilizers. Material developed from some of the data in that publication is contained in table 2.

TABLE 2

Effect of Fertilizers on 15-Year Accumulation of Organic Matter

Treatment of Soils	Fertilizers Applied Tons per Acre	Total Produce in 15 years Lbs. per Acre	Organic Matter in Soil at End Lbs. per Acre
No fertilizer	None	40,960	42,800
Complete fertilizer	5	117,910	60,800
Manure	190	139,670	73,600
Complete fertilizer and lime	7½[1]	120,605	49,000
Manure and lime	212½[1]	152,400	65,000

[1]Two and one-half tons of burned lime.

During the 15 years that preceded the sampling of the soil the land had grown 4 cultivated, 5 small-grain, 3 legume, and 3 timothy crops. All of these had been harvested and removed from the land. By the use of 5 tons

of fertilizer the total acre yield of dry matter had been tripled. Of special importance to this discussion, however, is the 40-per cent increase in the organic-matter content of the plow depth of soil of this fertilized area.

Somewhat higher yields were produced and more organic matter was accumulated by the use of 190 tons of manure than from 5 tons of fertilizer. This is to be expected, since the manure supplied much larger amounts of nitrogen and mineral elements than the fertilizer. Most of the organic matter of the manure was used up by soil microorganisms. The extra organic matter found in the soil of that area was largely that derived from the larger crops produced by the manure. Thus the higher the yield the greater the amount of roots and other crop residues that were available for plowing under.

Applications of lime increased crop yields at the expense of part of the organic matter. As a result of its use the soil microorganisms were stimulated to much greater activity. Nevertheless the limed soil still contained much more organic matter than that which had received no lime.

CARBON SAVED BY ADDING NITROGEN

The data revealed a close correlation between the carbon and nitrogen content of the soil of the several plots. The C:N ratio was approximately 10:1. A question arose as to whether one could save carbon by adding extra nitrogen to the soil. A study designed to find the answer was undertaken, in 1930, by one of my students at the Ohio State University. In this test organic materials having a wide range C:N ratios were used in such amounts as to supply 4000 pounds carbon per 2 million pounds soil. Ammonium nitrate was added to adjust the C:N ratios of these materials to 10:1, 5:1, and 1:1. At the end of a 12-month period the amounts of carbon remaining in the soil were as shown in table 3.

The differences are small, but they are important. They show that carbon can be saved by adding available N to highly carbonaceous materials when they are worked into the soil.

TABLE 3

Organic-Carbon[1] Content of Soils After One Year Following Addition of 4000 Pounds Carbon per Acre
Pounds Carbon per 2,000,000 Pounds Soil

	C:N 10:1	C:N 5:1	C:N 1:1
Average 10 materials	18,290	18,490	18,490
Soil check	16,360	16,360	16,360
Gain in organic carbon	1,930	2,130	2,130

[1]The factor from C to organic matter is approximately 2.

In 1940 I began work at the New Jersey Agricultural Experiment Station. Before many weeks had passed two phases of an organic-matter controversy were brought to my attention. One had to do with the diversity of opinion on organic matter on the part of the various members of the station staff. The other grew out of the need for the development of a better organic-matter program for the vegetable-growing areas in South Jersey.

OPINIONS ARE VARIED

The controversy resulted in the appointment of a committee of seven soil and plant specialists to formulate a statement on organic matter. These men found it possible to agree on the wording of a circular on the subject, but their personal interpretation of what that circular said were at wide variance. Some idea of the divergence in opinion may be gained from the following concepts that were expressed by the several individuals:

(1) Organic matter is not an essential constituent of soils.

(2) Well-rotted material is much more effective than crude organic matter for working into the soil.

(3) The chief value of a cover crop lies in its roots. They hold the soil in place, produce drainage channels, and aid in granulation.

(4) Young, green cover crops meet all the requirements for plowing-under purposes.

(5) Mature forms of organic matter are to be preferred because they are high in decay-resistent lignin.

(6) For each soil there is a fixed organic-matter level that cannot be materially raised.

(7) The natural organic-matter content of any soil can be raised to a higher level by the adoption of a suitable cropping program.

These concepts are not as far apart as they seem. All of these men were agreed on the importance of having soils contain as much organic matter as could be economically accumulated. The disagreement was primarily on two points: (1) to how much expense can one afford to go in supplying extra amounts of soil organic matter, and (2) should the aim be for fresh green material or for the more mature type?

LOAMS MAINTAIN HIGHER CONTENT THAN SANDS

An elaborate experiment was undertaken to throw light on these questions. It involved 45 organic-matter systems each replicated 4 times on two very different soil types. In some cases the organic matter was merely a winter cover crop that was plowed under early the following spring. In others extra organic matter was added to the soil at the rate of 2½ tons dry matter per acre annually. A third group consisted in taking one year off in four to grow organic matter to incorporate into the soil. Finally, crop-rotation programs consisting of two years of hay or grain crops and two years of cultivated crops were employed. The indicator crops were snapbeans and carrots. These crops were grown in succession each year, except for those cases in which the program prevented this.

To date, the only measurements made have been those of crop yields and the organic-matter content of the soil. From the data thus obtained a few cases have been chosen for presentation in table 4.

The essential points to be noted in this table are:

The Sassafras loam maintained about 1 per cent more organic matter than the Collington sandy loam.

Crop refuse and young green rye had greater value for raising crop yields than for increasing soil organic matter.

Corn stalks and peach-tree clippings were of much greater value on Sassafras loam than on Collington sandy loam.

(*Continued on page* 100)

TABLE 4

Effect of Various Organic-Matter Programs on Crops and Soils
Five-Year Total Yields and Amounts of Soil Organic Matter

Organic-Matter System	Collington Sandy Loam			Sassafras Loam		
	O.M. %	Beans gm.	Carrots gm.	O.M. %	Beans gm.	Carrots gm.
Lowest Yielders						
Refuse removed—no cover	1.13	7085	4921	2.16	7811	10,751
Refuse on soil—no cover	1.13	7446	6430	2.16	8086	11,222
Refuse on soil[1]—rye cover	1.22	8049	8644	2.21	8463	10,348
Highest Yielders						
Peach tree clippings[1]—rye	1.40	7940	8254	2.59	9110	13,069
Hyper-Humus[1]—rye cover	2.17	8785	8855	2.91	9325	11,556
Corn stalks[1]—rye cover	1.31	8116	9150	2.26	10049	14,302

[1]Crop refuse left on soil and rye grown in all cases.

The Effect of Cropping Systems on the Winter Population of Earthworms

HENRY HOPP AND HOMER T. HOPKINS

HENRY HOPP and HOMER T. HOPKINS are soil conservationists in the Erosion Control Practices Division of the Soil Conservation Service and are located at the USDA Research Center, Beltsville, Maryland. The authors gratefully acknowledge the aid of Jay C. Bryant in making the aggregate analyses.

EARTHWORMS are present in many agricultural soils. They have various chemical and physical effects, which are thought by some investigators to be of considerable significance for soil fertility maintenance (1, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18).[1] Earthworm populations vary under different conditions (2, 4, 6, 17).[1]

Recent statements, emanating mainly from practical farmers, claim that the earthworm population in the topsoil can be modified by farming practices. The validity of such claims has not heretofore been determined. In order to cast light on this hypothesis, earthworm counts were made in late winter of 1945, on the crop rotation plots of the Maryland Agricultural Experiment Station, College Park, Maryland. Since earthworms are effective in the formation of water-stable aggregates (8), the aggregation of the soil in these plots was also determined.

Procedure

The rotation plots were established in 1940 on a Sassafras loam soil. They measured 50 by 14 feet each and occupied a total area of approximately one acre. Various cropping systems were represented, including 2-year rotations and continuous cropping to cultivated crops, drilled crops, and sod crops. Thirty-six of these plots were sampled. Some of them were duplicate treatments on different parts of the area.

Earthworm counts were made twice at intervals of a month. The first counts were made between February 18 and 27, the second between March 20 and 26. The counts were made on cores of soil extracted by means of steel core samplers. Two samplers were used, one 6.6 inches and the other 8.0 inches, inside diameter. Four cores were taken on each plot with the smaller sampler, and three cores with the larger sampler. The total areas sampled per plot were 136.9 and 150.9 square inches, respectively. Both samplers extracted the soil to a depth of 7 inches, roughly the plow layer.

Soil samples from a depth of about 3 to 6 inches were taken from the plots on March 22. Each sample was a composite from several locations on the plot. The samples were dried, crushed lightly, and sieved to obtain 25 g. of aggregates, 3-5 mm. diameter. The proportion of these aggregates that did not break down into particles smaller than ½ mm. when gently agitated in water for 2 minutes was determined. After correcting for gravel, the remainder was recorded as water-stable aggregation. This procedure is a modification of that described by Yoder (19).

Results

The number and weight of earthworms, and the soil aggregation are given for each plot in Table 1. For convenience in examining the data, the results by major cropping systems are summarized in Tables 2 and 3.

Annual cropping systems are compared in Table 2. Soil cropped continuously to corn had the lowest earthworm population, and the lowest aggregation. This land was plowed in the spring and cultivated during the summer. Both

[1]Numbers in parenthesis refer to Literature Cited.

TABLE 1.—EARTHWORMS AND SOIL AGGREGATION UNDER DIFFERENT CROPPING SYSTEMS

Cropping system	Treatment variations	Cover at time of sampling	Plot numbers	Earthworms per acre[1] Number (Thousands)	Earthworms per acre[1] Weight (Pounds)	Soil aggregation (Percent)
Continuous corn[2]	Stover removed in fall	Corn stubble	B19	64	84	31
			C16	22	18	23
	Stover left, turned under in spring	Stover standing	B18	21	77	27
			C15	66	78	27
	Stover removed in fall, rye and vetch interseeded at last cultivation of corn, and plowed under in spring	Rye and vetch winter cover	C19	85	70	—
			D7	46	28	15
Continuous soybeans for hay (drilled)[2]	Soybeans cut for hay; disked and seeded to ryegrass in fall, plowed under in spring	Ryegrass winter cover	B11	109	104	43
			D1	86	36	19
Continuous soybeans for grain (drilled)[2]	Soybeans combined for grain; residue left on surface and plowed under in spring	Soybean residue on surface	B12	253	380	51
			D2	412	294	17
	Soybeans combined for grain; residue disced in; cheat grass planted in fall and plowed under in spring	Cheat grass winter cover	B13	85	85	44
			D3	155	124	22
	Soybeans combined for grain; residue disced in; rye planted in fall and plowed under in spring	Rye winter cover	B14	106	136	32
			D4	259	247	24
Continuous winter grain	Wheat, straw removed, idle during summer; plowed in fall for wheat	Wheat winter cover	H1	150	111	50
			H20	326	159	47
	Wheat, straw left; lespedeza in summer, not harvested; plowed in fall for wheat	Wheat winter cover	H4	288	126	50
			H17	419	490	46
	Barley, straw removed; lespedeza in summer, harvested for hay; alternately plowed and disced each year for barley; manured in spring	Barley winter cover	H9	392	173	50
			H12	506	308	71
	Barley, straw removed; then disced for soybean-sorghum silage; disced in fall for barley; manured in spring	Barley winter cover	H10	379	212	68
			H11	380	239	74
2-year rotation	1st year of rotation: corn, stover removed in fall[2]	Wheat winter cover	C8	85	50	43
			D13	198	100	38
	2nd year of rotation: wheat; timothy and red clover, not cut	Sod	C2	230	148	45
			F2	588	509	49
	1st year of rotation: corn, stover removed in fall	Wheat winter cover	C7	42	20	56
			D12	22	38	39
	2nd year of rotation: wheat; sweet clover and lespedeza, not cut	Sod	C3	274	300	56
			F3	524	434	41
Continuous sods	Alfalfa-grass mixture	Sod	B1	504	287	42
			E1	347	380	68
	Lespedeza-grass mixture	Sod	B8	252	266	84
			B10	264	289	81
	Orchard grass	Sod	—	674	258	76
	Timothy	Sod	—	172	194	63

[1]Each value is the average of 2 samplings, one in February and the other in March.
[2]Land prepared in spring by plowing, dragging and harrowing.

the earthworm population and the soil aggregation were higher in the non-cultivated plots that were grown in drill rows.

Continuous cropping with drilled soybeans resulted in somewhat more favorable conditions for earthworms and better aggregation. Removing all the top growth for hay (B11 and D1) was less beneficial than returning the residue of combining to the soil (B13, B14, D3, D4). The most favorable conditions for earthworms in soybean cropping were obtained in plots where the residue was left on the surface as a mulch for the winter. The earthworms in these plots were practically as numerous as in sod land.

Continuous winter grain was also relatively favorable for earthworms. This was true even of the winter-grain plots in which a summer legume followed the grain. Little difference resulted whether the summer legume was left unharvested (H4, H17) or was removed (H9 to H12). However, removing all top growth from winter-grain plots and leaving the land idle over summer was somewhat less beneficial to earthworms (H1, H20).

Continuous sods, on the whole, favored large earthworm populations. Alfalfa-grass plots (B1, E1) contained more earthworms than lespedeza-grass plots (B8, B10), and orchard grass plots contained more than timothy.

TABLE 2.—EARTHWORMS AND SOIL AGGREGATION IN VARIOUS ONE-YEAR CROPPING SYSTEMS.

Annual Cropping Plan	Earthworms per acre Number (Thousands)	Earthworms per acre Weight (Pounds)	Soil aggregation (Per cent)
Corn	51	59	25
Drilled soybeans for hay	98	70	31
Drilled soybeans for grain; residue turned in for winter cover	151	148	30
Drilled soybeans for grain; residue left on surface	332	337	34
Winter grain, idle during summer	238	135	48
Winter grain, legume during summer	394	258	60
Legume sod	342	306	69
Grass sod	423	226	70

Soil aggregation paralleled the earthworm population fairly closely for the major cropping systems, as shown in Table 2. However, among plots with similar cropping systems, there were often large aggregation differences. These differences did not correlate with the number of earthworms, either. Variations in soil texture and in the topographic position of individual plots appeared to cause at least some of these discrepancies in aggregation.

The changes in earthworm population as a result of rotating corn, winter grain, and hay crops were marked. Table 3 shows that the earthworm population in the winter following the row crop year was lower in annual row cropping than in the 2-year rotation. After the second year of the 2-year rotation, the earthworm population was several times greater than after the first year. Soil aggregation was sustained at a higher level in the 2-year rotation. After the corn year, aggregation was higher than in annual row cropping, while after the hay year, aggregation was lower than in continuous sods.

TABLE 3.—EARTHWORMS AND SOIL AGGREGATION IN RELATION TO CORN ROTATIONS.

Cropping system	Crop at time of sampling	Earthworms per acre Number (Thousands)	Earthworms per acre Weight (Pounds)	Soil aggregation (Per cent)
Corn annually	None, or winter cover following corn	51	59	25
2-year rotation	Wheat, following corn	87	52	44
	Hay, following wheat	404	348	48

DISCUSSION

The most important fact revealed by this study is that winter earthworm populations as high as in permanent sod can be maintained on cropped land by proper management methods. Winter grain-summer legume cropping appeared to be especially favorable for earthworms.

Under continuous sod, the winter earthworm population was several hundred thousand per

acre. This population was approximately maintained: (a) in continuous winter grain-summer legume plots, (b) in soybean plots that were surface mulched over winter with the combine residue, and (c) in the hay plots of the rotations. The winter earthworm population was markedly less than that on sod in (a) continuous corn plots, (b) corn plots of the rotations, and (c) soybean plots that were not mulched. Turning in a sod, green manure, or crop residue did not prevent the reduction in earthworms.

It is interesting to note that the cropping systems with low earthworm populations were associated with early spring plowing (i.e., plowing at the time land is normally prepared for corn). This reduction was apparently avoided on the land covered with a surface mulch of soybean residue during the fall and winter. On the other hand, soil disturbance in the late spring (after the winter-grain harvest) did not cause a reduction in the number of earthworms. This was true even of the plots that were cropped rather heavily in the summer, such as those in which crops of silage or hay were grown after the winter grain was harvested.

A point that should probably be emphasized is that these counts were made at only one season of the year and at only one location. Before generalizing too broadly on these findings, further studies would be desirable at other locations and in other seasons of the year.

Whether the maintenance of the earthworm population actually has a beneficial effect on crop yields still remains an unanswered question, despite considerable previous work. The answering of this question would now seem to be rather urgent, in view of the present finding that earthworm populations can be influenced markedly by cropping practice.

SUMMARY

Earthworm counts and soil-aggregation tests were made in the late winter on 36 crop-rotation plots of the Maryland Agricultural Experiment Station, College Park, Maryland. Earthworm populations and soil aggregation varied widely with the cropping systems. Continuous corn, with or without green-manuring, resulted in the smallest average earthworm population. Continuous drilled soybeans, when harvested for hay, resulted in a somewhat larger number of earthworms. When the soybean grain only was removed, and particularly when the residue was left on the surface, the earthworm population was still higher. Continuous winter-grain cropping was especially favorable to maintenance of earthworms. When a legume hay was grown in the summer following the winter grain, earthworm counts as high as those in continuous sods were obtained. In the rotation plots, the earthworm population following corn varied inversely with the frequency of the corn year. In the second year of a 2-year rotation, earthworms were as abundant as in continuous sod. Soil aggregation was closely correlated with earthworm populations in the annual cropping systems. In the rotations, where row and sod crops were alternated, aggregation was higher than in annual row cropping, but lower than in continuous sods.

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(*Continued on page 98*)

Soil Conservationists for All the World

WILLIAM X. HULL

MR. HULL is a soil conservationist of long experience who has worked throughout the United States and in several Latin American countries. For several years he has been in charge of the training of foreign students for the Soil Conservation Service.

WHEN PEARL HARBOR startled the world and America entered World War II, many countries found that the ocean lanes for the shipping of food stuffs had suddenly become nonexistent. Most countries then had to rely mainly on their own agriculture for feeding their people. To importing nations this became a vital problem. It was then that these countries, after taking stock of their resources, found that erosion had taken a great deal of their good soil down to the seas. They realized with a shock that it was time something be done immediately to stop this waste, to rebuild their agriculture, and to feed their people. They had all known for years that soil and, therefore, agricultural production and income, were being lost.

The people of most nations had thought there was plenty of time to attend to the saving of their soil. The "mañana" of Latin America seemed time enough to do it. But time would not wait; the losses from the action of the elements and from faulty farming went right on; much soil slipped away and was gone forever. (Figures 1 and 2.) Since the war's end these countries have found that drastic action is necessary to curb the loss. Today in this world-wide crisis of food shortage, more and more countries are looking to the United States for help and guidance. The Soil Conservation Service of the United States Department of Agriculture, through the techniques developed during the eight years preceding Pearl Harbor, had become the world leader on matters of soil and moisture conservation.

On July 1, 1942, the Soil Conservation Service began an experiment in the training of Latin American technicians in the methods of soil and water conservation. During the next eighteen months, twenty-five agricultural technicians from thirteen countries of Central and South America spent twelve months each with the Service. (Figure 3.) The training as finally worked out consisted of work-while-learning courses. Owing to language difficulties each trainee remained in Washington for about four weeks for intensive training in English. He was then sent to the field to join one of the conservation survey parties for a period of six weeks to two months. Here he became a member of the survey party. He learned how to make soil and conservation surveys and how to classify the land as he found it. He dug holes and made borings for sampling the soil. By this close association with Soil Conservation Service technicians his English improved markedly. It was also found that two or more trainees should never be located at the same work unit or office at the same time; to do so greatly hindered their acquisition of English.

Following this period with the surveyors the trainee was placed with a farm-planning unit. Here he remained for about six months. With this unit he learned how to make farm plans; how to plan, layout and establish the various conservation practices, how to put on publicity campaigns; and most of all, he learned the way of life of the average United States farmer. His second period of training was so located that the crops, topography, soils, or climate would have some similarity to his own country. It is very seldom possible to obtain exact parallels with other countries even in this great land of ours. We grow no coffee, chocolate, cocoanuts and few other crops native to the tropical countries from which these men come.

During the subsequent two months the trainee

Figure 1—Destroyed crop field near Tlaxcala, Mexico, exemplifies erosion widespread throughout Latin America.

receives training in and observes other conservation practices, often where the topography and agronomic conditions differ from those at his first two locations. Before leaving the second location the trainee must be able to work with the farmer or ranch operator and make a complete farm or ranch plan. He must also be able to establish the necessary conservation practices. From each location, he visits different experiment stations to observe the work and the results that may be of special value to the agriculture of his country.

The final month of his fellowship is spent in Washington. Here he writes a report or thesis on his training and outlines the problems of his country and what plans can be made for the conservation of its lands and people.

Some minor changes have been made in this method of training since the first group came in 1942 and 1943, but basically the method has been found successful.

Upon completion of the year's training the technician returns to his home country to take his place in its agriculture and to help in its improvement by the techniques of soil and water conservation which he learned in the United States. The selection of the technicians who formed this first class of trainees was very carefully made. This program was a part of the good will policy of the United States. A prospectus was written covering the training to be given by the Soil Conservation Service with specifications as to the qualifications necessary for a technician to become acceptable. The actual selection was made by a committee in each country, made up of a representative from the United States Foreign Office, the local Ministry of Agriculture and the Agricultural University. The acceptance or rejection of a candidate was the prerogative of the Soil Conservation Service in Washington. One important stipulation in the qualifications—and this has proved to be paramount—is that the applicant must be in the employ of his government, a professor in the university, or in the employ of some corporation fostering agriculture and working with farmers. It was also agreed that upon the completion of his training and upon return to his native country the trainee be employed in work to further soil and moisture conservation. Only one of the number trained has failed in this latter condition.

The first group of twenty-five trainees, as well as a much smaller group received each year, were furnished transportation from their home

Figure 2—Steep Central American hillsides produce poor corn yields and result is disastrous loss of topsoil.

to Washington and return. They were also given a small amount for actual subsistence while in the United States. These costs are a part of the good will policy of the United States.

Two years after the first class completed training a survey of the results showed that the men had, in nearly every case, been advanced to higher rank in their home countries. Some were made heads of new divisions which their government created to apply conservation measures to the farms. By this time the success of this training was becoming known far beyond the confines of Latin America. Inquiries were received from several countries as to the possibility of their nationals receiving this training without

(*Continued on page 94*)

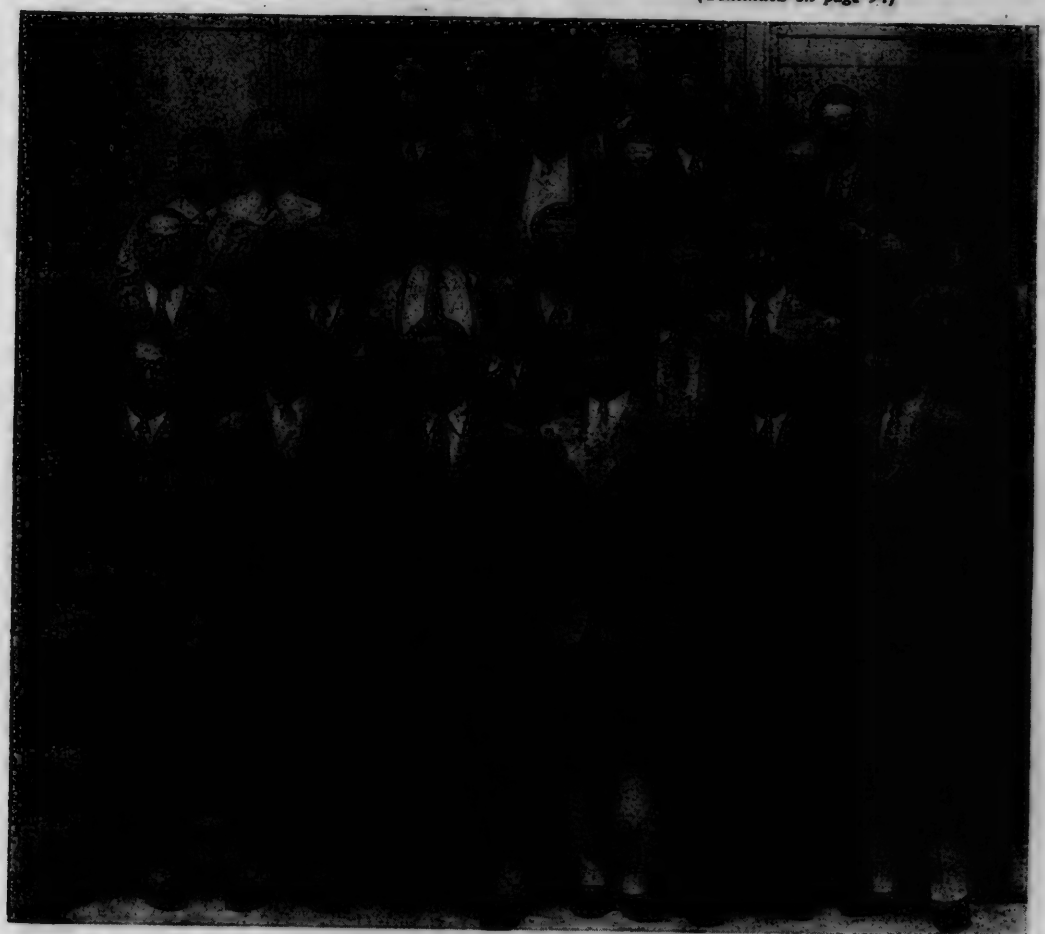

Figure 3—First group of Latin American trainees in soil conservation to study in the United States, 1942-43. Front row, left to right: Jose A. Rugeles, Venezuela; Manuel Rodriquez, Chile; Rodrigo Orellana, Ecuador; Ricardo Leon Manzo. Mexico; Casiano V. Quevedo, Argentine; Arturo Fernandez, Costa Rica. Second row, left to right: Alfredo G. Antonelli, Paraguay; Fernando Sayan, Peru; Gonzalo A. Moreno, Ecuador; Sebastian Romero, Venezuela; Jose Juaregui, El Salvador; William X. Hull, USA; Jose Suarez, Chile; Emilio Zamudio, Mexico. Third row, left to right: Feline Andrade, Mexico; Jader T. de Rezende, Brazil; Mario A. Baracco, Peru; Javier G. Paredes, Mexico; Paulo P. P. de Melo, Brazil; Carlos A. Fynn, Uruguay. Back row, left to right: Ricardo Jahn, Venezuela; Lucio R. Garcia, Cuba; Silvino A. Batista, Brazil; Anthony Lespes, Haiti; Arturo Somoza, Argentine; Humberto Ortega, Mexico.

Program of the First Annual Meeting of the Soil Conservation Society of America

The program for presentation at the first annual meeting of the Soil Conservation Society of America, which follows, will be held in the Morrison Hotel, Chicago, Illinois.

THURSDAY, DECEMBER 12

Morning Session

9:30 A.M. Call to Order
R. H. Musser, President and Presiding Officer.

10:00 A.M. General Session
Chairman: C. E. Young, Field Representative, office of the Secretary, U. S. Department of Agriculture.
Paper: *"Soil Conservation In Our Democracy,"* H. C. Byrd, President, University of Maryland.
Reviewers: M. L. Wilson, Federal Extension Service; Arthur Moore, Editor, Chicago, Illinois.

12:00 N. Luncheon

Afternoon Session

1:00 P.M. *"The Science of Soil Conservation"*
Round Table I: *"Its Foundation, Development, and Scope."*
Chairman: J. H. Price, Forest Service.
Panel Leader: R. E. Yoder, Ohio State University.
Members: A. F. Gustafson, Cornell University; H. C. M. Case, University of Illinois; C. H. Bailey, University of Minnesota; H. H. Finnell and E. A. Norton, Soil Conservation Service; H. S. Benson, Thompson Farms, Indiana.

3:15 P.M. Round Table II: *"Its Understanding and Acceptance."*
Chairman: R. K. Bliss, Iowa State College.
Panel Leader: Kirk Fox, Editor, Des Moines, Iowa.
Members: E. C. McArthur, State Assoc. of Soil Conservation District Supervisors, Gaffney, S. C.; Kenneth Chalmers, Soil Conservation Service; H. S. Steavenson, St. Louis Chamber of Commerce; The Very Reverend George J. Hildner, Missouri; H. C. Ramsower, Ohio State University. V. L. Nickell, State Department of Instruction, Illinois.

Evening Session

6:30 P.M. Dinner Meeting
Chairman: Charles Brannan, Assistant Secretary, U. S. Department of Agriculture, *"Review of the Founder's Work Leading to Creation of the Society."*
Founder's Address: *"Soil Conservation in Our World Ahead,"* H. H. Bennett, Chief, Soil Conservation Service.
Business Meeting: Society Officers Presiding.

FRIDAY, DECEMBER 13

Morning Session

8:30 A.M. *Technical Phases of Soil and Water Conservation.*
Chairman: Firman E. Bear, Rutgers University.
"Soils," R. J. Muckenhirn, University of Wisconsin.
"Crop Land," Grover Brown, Soil Conservation Service.
"Grazing Land," B. W. Allred, Soil Conservation Service.
"Woodland," R. E. McArdle, Forest Service.
"Engineering," G. D. Clyde, Soil Conservation Service.
"Wildlife," Warren W. Chase, University of Michigan.

12:15 P.M. Luncheon Meeting
Chairman: Fred A. Wirt, J. I. Case Company, Racine, Wisconsin.
President's Address: R. H. Musser, Milwaukee, Wisconsin.
Election of Officers.

Afternoon Session

2:45 P.M. Round Table III: *"The Science of Soil Conservation in Its Application."*
Chairman: W. R. Van Dersal, Soil Conservation Service.
Panel Leader: R. Y. Bailey, Soil Conservation Service.
Members: Alex Gale, Director, St. Joe River Soil Conservation District, Michigan; S. P. Lyle, Federal Office of Extension; Herschel Hecker, Soil Conservation Service; E. W. Mundie, Extension Service, Virginia; V. W. Woodman, Soil Conservation Service; Thomas Schmidt, Farmers Home Administration.

4:30 P.M. Adjournment

From the President

SOIL conservationists from all over the Western Hemisphere will meet in Chicago, December 12 and 13, at the first annual meeting of the Soil Conservation Society of America. The meeting will provide an opportunity for the entire membership to discuss objectives, accomplishments, and make plans for the year ahead.

There is a big job to be done if we are to forward the science of soil and water conservation and to maintain and develop the standards of the science. This has been the fundamental premise in planning the program for the first annual meeting.

During the first day, the development and scope of the science will be highlighted. The broad, over-all picture of soil and water conservation and its implication on the affairs of the world will be fully explored.

An important feature of the discussion will revolve around the proper understanding and universal acceptance of the conservation of soil and water resources. The membership will delve into the contributions that related fields are making to this comparatively new science. I think all of us will be immensely interested to hear some of the Nation's outstanding conservationists relate and describe how the various fields fit into and support the science of soil and water conservation.

An additional feature of the program will deal with matters pertaining to the science of soil conservation in its application. A thorough discussion of this subject has been arranged.

This will be the first opportunity for the entire membership to discuss and participate in the business affairs of the Society.

The fact that our membership and technical contributions stem from all types of professions related to the science of soil and water conservation is of particular significance. Biologists and foresters, engineers and agronomists, soils technicians and economists, and many other technical and professional workers have a common cause and purpose in the objective of our society—the advancement of the science of soil and water conservation. Each and every profession can make a contribution to the objectives which have been set forth. The membership of the Society has the responsibility in paving the way for progress on the part of all concerned in attaining these objectives.

I hope this meeting will afford the basis for consideration of our future program. Although time does not permit a formal discussion of the future program during the meeting, there will be an opportunity for further thought and informal discussion. Although the technical phases of the sciences of soil and water conservation are paramount in their importance, I think we should never lose sight of the fact that conservation of soil and water is more than a technical knowledge; it is a philosophy—a way of life. For this reason it is imperative that we consider ways and means of creating an understanding on the part of all people regarding the importance of its intelligent use.

During the business portion of the meeting, officers of the Society will be nominated and elected. The constitution and by-laws provide that candidates for office shall be made by nominations from the floor. The officers shall then be elected by a majority vote of those present. A proxy may be given to a person entitled to vote. Proxies should be properly witnessed and submitted to the Secretary for verification of the right of the person to vote at the annual meeting.

The program committee has done an excellent job—they have secured outstanding talent and provided for interesting discussions. The success of our first annual meeting rests with the interest and participation of its membership.

H. H. Bennett

SOIL CONSERVATIONISTS

(*Continued from page 91*)

expense to the United States. It was then decided that other countries which were benefiting from this training, provided by the Soil Conservation Service and other bureaus of the government, should bear some or all of the expenses of their trainees.

Beginning in 1944, scholarships were awarded which carried no grant of funds. The selection of the trainees is still carried out much as before. The financial backing of these trainees might be from another government, a corporation, an educational or other foundation, or from private sources. But whatever the source of the trainees' support, the type of training will be the same as for the trainees financed by the United States. And, as a result, up to September 1, 1946, the Soil Conservation Service has trained, or has now in training, 94 agricultural technicians from 31 countries, from Latin America and nations in Europe, Asia, Africa and Australia. Of these 94 men 44 have received financial assistance from the United States and 50 have been supported by other means. There are now pending 40 applications from 13 countries for this training, and not one of the scholarships issued on these applications will receive any financial assistance from the United States.

The trainees accepted and trained with the Soil Conservation Service are all mature men who have had, since graduating from their respective universities, several years of experience in agricultural work in their home lands. No undergraduate student, or one who has just graduated from his college, is accepted. There are not excluded, however, agriculturists in the employ of corporations whose main fields lie in agriculture—such as fertilizer companies, implement manufacturers, etc. In fact, there have been successful trainees from each of these industries. One large plantation owner in a South American Republic requested that his son be trained so that he could apply soil and moisture practices to his plantation and increase its production. This trainee proved to be one of the best.

The several countries consider that this training greatly increases a technicians value. Former trainees now hold such positions in their home lands as: State Secretary of Agriculture, Chiefs of bureaus or divisions, Heads of departments, full professors at agricultural colleges, Heads of research stations, Inspectors of agriculture and many other important positions, all having to do with the advancement of soil and moisture conservation.

In addition to the foreign technicians trained by the Soil Conservation Service, the number of official visitors has increased tremendously since the war's end. These visitors come here to acquire some special knowledge or to obtain a quick overall picture of the work of the Service. Tours, long or short, are arranged for these people. Within the past six months, extended tours have been arranged for and carried out by the Director of Experiment Stations and his assistant from the Belgian Congo; the Director of Publicity of the Soil Conservation Department of the Union of South Africa; directors of seven cooperatives from Palestine; directors of agriculture from two Australian provinces; nine technicians from the Netherlands East Indies; five technicians from the State of Sao Paulo, Brazil, the directors of agriculture from two Indian provinces, and many others. These men were all sent by their respective governments to the Soil Conservation Service to obtain knowledge as to ways and means to better their own agriculture through soil and water conservation.

Several countries have recently passed legislation for the advancement of soil and water conservation and its legal status is being promoted by a number of governments. It has taken many centuries—since prebiblical times down to the present—for the world to learn that the wasteful methods of agriculture and the mistreatment of the soil must stop if the world is to survive. The keen interest shown by many countries of the world in this training of technicians indicates that progress is under way in halting the devastation of soil erosion through careless land use.

Conservation Needs Educational and Organizational Drive

R. K. BLISS

R. K. BLISS is Extension Agriculturist for the Agricultural Extension Service, Iowa State College of Agriculture, Ames, Iowa. This article presents his views of the need for and aggressive educational effort to interest everyone in soil conservation.

FIFTY YEARS ago Professor Shaler of Harvard University in discussing the dangers of soil erosion wrote—"If soil erosion cannot be prevented we must look forward to a time —remote it may be, yet clearly discernible— when our kind having wasted its inheritance, will fade from the earth because of the ruin it has accomplished."

Professor Shaler might have stated it this way—if we through careless cultivation and management of the soil steadily continue to lose more fertile soil than nature can rebuild it is only a matter of time until mankind will perish from the earth.

It is no exaggeration to say that soil conservation is one of the paramount long time problems confronting us. Our strength as a nation, in fact our very existence, will depend at some future time on how well we succeed in solving it.

In an agricultural state such as Iowa, soil conservation is of very special immediate importance. Soil conservation is Iowa's greatest long time economic problem. Soil fertility is by far our greatest natural resource. We are all, both city and country, largely dependent upon it. If we succeed in maintaining the soil our well being over a long period of time will be assured. If we continue to permit the soil to deteriorate it will only be a matter of time until Iowa land will become barren.

We in Iowa have been especially favored. Nature has given us a very rich and productive soil. It took millions of years to build the rich soils of Iowa. It should be the settled policy of all our people to guard zealously this heritage of soil resources and hand it on in full wealth and productiveness to those who follow.

How well have we preserved our soil resources? This year completes 100 years of time since Iowa became a state. It is well for us to review briefly our stewardship or trusteeship of the soil. Certainly we can boast in astronomical figures of the production of grain and livestock. This has been particularly true in the war years during which time Iowa farmers rendered a great patriotic service to the war effort. But just as certainly we can also state in astronomical figures the story of our soil losses. Several years ago our soil scientists estimated that 30 billion tons of topsoil had been lost to Iowa through erosion since the state was brought under cultivation. This is an amount of soil almost beyond the imagination.

There is good reason to believe that soil erosion has gone on faster during the past three years than in any other three consecutive years of our history. This is because of the large amount of land under cultivation to meet war food demands and also because of torrential rains at planting time when the ground was bare and unprotected. The resultant loss of soil has been appalling. During the heavy dashing rains at corn planting time two years ago it was estimated that Iowa lost 150 million tons of soil within two weeks.

Anyone who will take the trouble to drive through the hilly and rolling parts of Iowa and carefully observe what has taken place in regard to soil will realize the immediate importance of soil conservation. Such a trip will reveal farm after farm beginning to show yellow on the slopes. This means that the top

layer of rich productive soil is largely gone. It means that such fields will become increasingly less and less productive unless effective erosion control practices are developed. The farmer who farms them will have less to spend and the merchant who supplies him with goods will make fewer and smaller sales. Erosion on the farms results almost immediately in loss of trade to towns and cities.

But there is another very important reason while all of us are directly interested in maintaining the fertility of Iowa soils. There is an ever increasing mass of evidence to support the proposition that animal health is largely dependent upon soil health. In short, the soils that are sad and thin and sickly, produce animals that are also sad and thin and sickly. There seems to be little or no doubt but what this is true.

It then follows that the people who eat the animals, grains and vegetables that are produced on thin, eroded and sickly soils are also much more likely to be sickly and subject to the inroads of disease. This is based on the assumption that we are literally what we eat. If this is true what then could be more important for the immediate welfare of our people than to improve the fertility and health of the soil? What could be more important than the job not only of saving the fertility of our present soil but in building all of our soils to a high state of health and fertility.

We used to think that poor people and poor soil just naturally got together because they were both poor. It is more correct to say that people became poor because they were living on and eating the products of thin, eroded, sickly soil. In such cases they did not get the nutrients they needed for strong healthy bodies and became weak and ill like the land on which they lived.

Thus both from the long range economic standpoint and from the immediate human welfare standpoint, all of us are deeply concerned about the soil. It does not matter where we live. We all have the same deep concern about soil. The child in the city who eats food shipped in from poor sickly land is in the same danger if there is a danger, as the child living on the land. During the past year we have had many discussions in this state about the inadequacy of our state institutions to take care of the sick, the deranged and the criminal elements of our population. Yet we do not have many more people living in Iowa than we had forty years ago. Can it be that the incidence of sickness, crime and insanity is on the increase? And if so, to what is it due? Perhaps what people eat and the soil on which it is grown has something to do with this situation. This probability is at least worthy of careful investigation.

Iowa has already suffered terribly from soil losses. We now have abandoned land. We now have sick land. *Thus far our efforts in soil conservation have been wholly inadequate.* Farmers go on planting corn, beans and other cultivated crops up and down hills. Such a system is made to order for carrying soil away from the field to the creek to the river and later to the Gulf of Mexico. Under such a system of cultivation each cultivator shovel makes a channel to carry the water and soil at a faster rate.

Planting corn and other inter-tilled crops on the contour has made some progress. But the percentage of crops so planted is still very small. Planting inter-tilled crops around the hill instead of up and down the hill would save millions of tons of Iowa soil each year and would also increase the yield of crops. We have the necessary information to save our soils. We know what to do. For more than 50 years our Experiment Stations and the United States Department of Agriculture have been gathering information, and it is available for use.

We also have the organization machinery. Each Iowa county has a county extension director and a county farm bureau which is also the county extension educational organization reaching all parts of the county. Some seventy-eight Iowa counties have soil conservation districts. The United States Soil Conservation

(*Continued on page* 102)

Notes and Communications

Dear Sir:

I think the first issue of your Quarterly is extremely creditable. It has the right stuff in it and—more important and more difficult—it has the right tone.

Russell Lord
Editor, *The Land*
Bel Air, Maryland

Dear Sir:

I enjoyed reading the first issue of the Journal. The style is different than most professional journals, and too, the feature articles were all interesting and especially instructive to those of us in the field.

The Book Review section was welcomed. Keep this going because we often miss knowing about these publications, for they are not otherwise called to our attention.

The Pictorial section will always interest me. Good pictures tell more than words about how soil conservation work is being carried on in other parts of the world.

We in the field are interested in knowing more about new practical conservation ideas and under what conditions they are succeeding in other parts of the country; also the latest information about the science of soil and water conservation. This is extremely important and should be further developed in the Journal.

Frances T. Bowne
District Conservationist
Pittsburgh, Pennsylvania

Dear Sir:

By and large, the first issue of the Journal looks very good to me. I like your editorial statements as to the purpose of the Journal and the Society. I am sure I recognize difficulties under which you men were working in trying to set up the first issue, both in kinds and amounts of material to use. I feel that comments from the membership should be encouraged and should find an important place in the magazine. Dr. Bennett's article is splendid. I think we can go on from there in the development of the science, showing how we actually develop the program of land use and soil conservation scientifically and practically on each acre of land. I think future issues can well deal in that vein. The flood control and drainage articles were both good. Again in drainage, irrigation, and flood control, I think we can develop step by step the scientific approach in soil conservation.

R. H. Musser, *President*
Soil Conservation Society of America
Milwaukee, Wisconsin

Dear Sir:

Hats off to the new Journal! It does great credit to our Society and to our editors. It is no small triumph to produce a magazine which can be sternly professional without being stuffy. I like its looks, its substance, and its promise of values to come.

Wellington Brink
Editor, *Soil Conservation*
Washington, D. C.

Report Changes of Address

IF YOU failed to get the first number of the Journal because of a change in address, or know some one who did not receive his copy, a correct address sent immediately to J. H. Christ, Secretary-Treasurer, Soil Conservation Society of America, P. O. Box 671, Portland 7, Oregon, may assure delivery of the next issue. It is necessary that any change in address be reported promptly.

DEAR SIR:

Congratulations, Mr. Editor, on your first edition of the JOURNAL. It is an excellent beginning.

At present most of the readers of the JOURNAL are probably employees of the Soil Conservation Service. However, it is my belief that as circulation increases more professional workers representing allied fields will read the JOURNAL. Therefore, in order to better promote and advance all phases of the conservation of soil and water resources, the subject matter needs to be sufficiently varied to reach many conservation interests.

It is important that articles appearing in the JOURNAL are not all written by professional Soil Conservation Service employees. And above all, avoid an over-abundance of highly technical papers. Several of the Journals published by other societies have long since passed through the "mania for technical articles."

I am firmly convinced that the soil conservation district approach is the most efficient medium through which the various phases of all conservation activities can be effected. For the first time in the history of our country we have a means by which all conservation activities can be coordinated into one program. This makes it possible for land owners to receive efficient on-the-ground assistance with any conservation problem. My convictions concerning this became more firmly cemented during the recent American Forestry Congress when numerous men, all prominent in the field of forest conservation, voiced their opinion that the best method of providing a sound forestry management program to small woodland owners is through locally organized soil conservation districts.

I strongly urge that future subject matter in the JOURNAL cover all fields of conservation that concern land owners. Woodland management, as it relates to the science of soil and water conservation, is highly important.

D. E. HESS,
Public Relations
P. H. Glatfelter Co.

EDITORIAL

(*Continued from page 54*)

In order to bring to members of the Society something of what has been done by these predecessors with whom most of us are less familiar than the contemporary names so much before us, the JOURNAL proposes to carry reviews and analyses of classical work in our field. If you have an interest in what one of these men has done, an analytical summary of it will be appropriate for the JOURNAL's pages. If you wish to review a book one of them once wrote, the JOURNAL can profitably use a comprehensive synopsis of it, with interpretation of its historical significance and its influence on modern soil conservation. Let the JOURNAL be a medium for the best in past as well as current thought.

WINTER POPULATION OF EARTHWORMS

(*Continued from page 88*)

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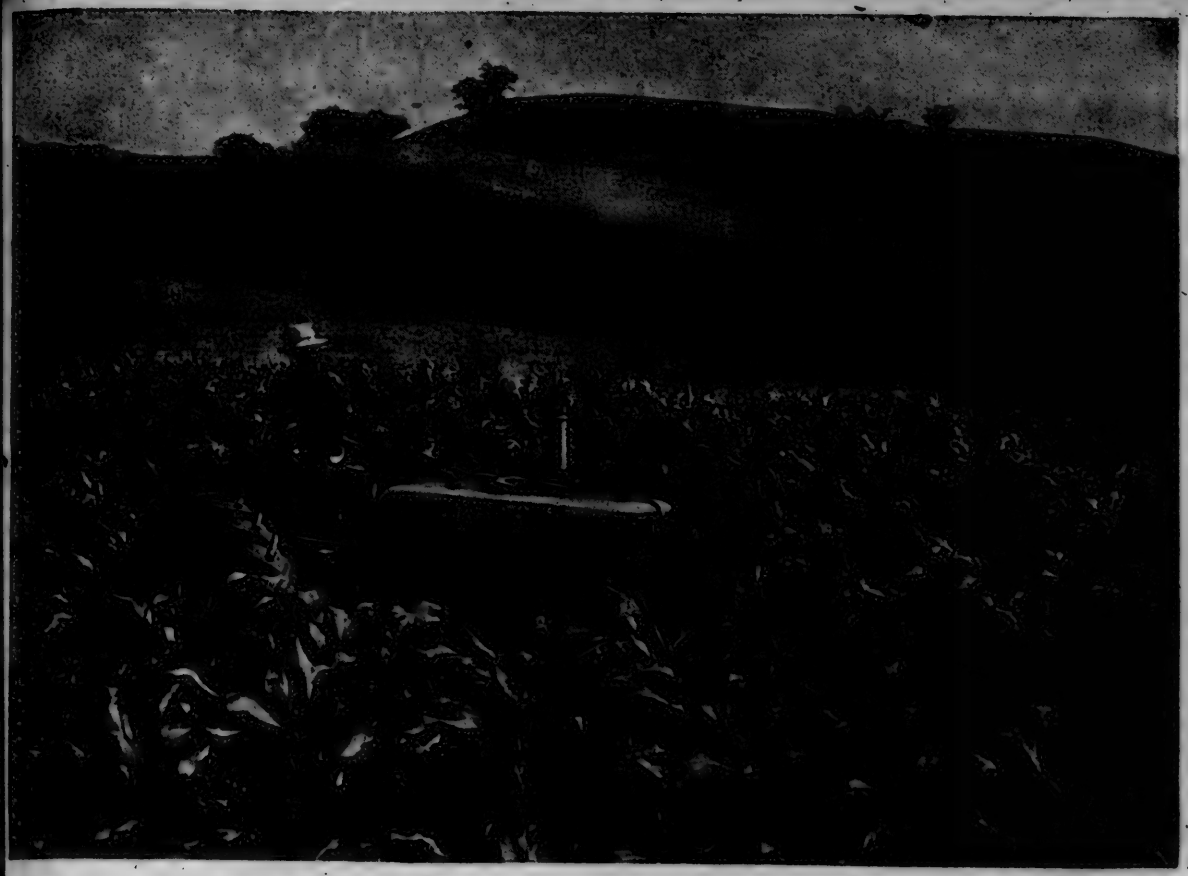

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But there's much more coming!

Self-Propelled Combines . . . One-Man Pickup Hay Balers . . . Mechanical Cotton Pickers . . . Spreaders for Fluid Manure . . . Farmall Cub Tractors and Tools . . . New Side Delivery Rakes . . . Dry and Green Hay Choppers . . . Power Loaders . . . Smaller Balers, Combines, Corn Pickers . . . Cut-Off Corn Pickers . . . Sugar Beet Harvesters . . . Home Freezers . . . Touch Control.

These new products are being prepared for American farmers by International Harvester engineering and productive skills. *Many of these machines will not be ready for many months to come.* All of them are dependent on plant capacity and availability of men and materials.

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Fight Soil Erosion!

Strip-cropping is being practiced more and more as a recommended soil conservation measure on sloping, hilly fields. It is a profitable example of *better land use* . . . Your regular Farmall Tractor and Equipment is designed for FARMING ON THE CONTOUR.

INTERNATIONAL HARVESTER

HARVESTER *Leads the Way*
***in* POWER-and-MACHINE FARMI**

SOIL ORGANIC MATTER

(*Continued from page 84*)

The percentage organic matter accumulated in the soil was of much less importance than its nature.

Plants responded to soil differences that were not detected by the chemist.

On the Collington sandy loam carrot yields were raised 30 per cent by turning under crop refuse, an additional 45 per cent by turning under rye, and further 10 per cent by adding cornstalks.

On the Sassafras loam the increases in carrot yields from turning under crop refuse and rye were nil, but cornstalks raised the yield 33 per cent.

PERSONAL CONCLUSIONS

My conclusions about soil organic matter are somewhat as follows:

Inorganic fertilizers are highly effective agents for increasing the amount of organic matter in soils.

The organic-matter problem is readily solved when rotation with a sod crop is practiced and lime and fertilizers are applied in liberal amounts.

Excessive loss of organic matter can be prevented by adding extra nitrogen to straw, cornstalks, and similar materials that are low in this element.

Fresh green organic matter is of more value in a sandy soil than in a heavy one.

Crude types of organic matter are of more value in a heavy soil than in a sandy one.

Soil organic matter is of little or no value in sand cultures in which plants are fed continuously with nutrient solutions.

Soil organic matter is of less value in soils of the intermediate loam types than in either the lighter and heavier types.

The effectiveness of sod and cover crops as agents for preventing erosion is self-evident.

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BIOLOGY OF SOIL STRUCTURE

(*Continued from page 75*)

matter decay. A good structure holds to a minimum the processes of anaerobic microorganisms, such as the reduction of sulfates or nitrates to forms unavailable or toxic to the plants.

A desirable soil structure can be maintained by following a rotation including a sod crop, and frequent liberal use of manures and crop residues.

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TERRACES.. "Eaves troughs" for the Missouri Watershed

PICTURED here is Exhibit A in the case against soil erosion, a test tube filled with water from the mud-swollen Missouri River. There is unmistakable evidence in the ⅛-inch layer of fertile silt which has settled to the bottom of this glass tube.

Here is a revealing sample of the 100,000,000 *tons* of topsoil swept away every year by this one river alone. When spring and summer rains begin, the Missouri's sediment load jumps from 10,000 to 3,000,000 tons a day. That's the topsoil equivalent of a 100-acre farm every five minutes.

Something can and is being done about it. Like almost every farming territory, the Missouri watershed needs "eaves troughs" — terraces and contour strips to control runoff water. Allis-Chalmers is co-operating with soil conservation engineers in demonstrating tractor methods of terracing with moldboard and disc plows, strip cropping, constructing ponds, waterways and reservoirs.

All these operations can be done with regular home-owned tractor equipment. Costly graders and heavy crawler tractors are no longer required.

By holding rain water on the slopes, modern tractor plows are providing life-giving moisture to crops and healing the cancerous erosion eating into our farmlands.

NEW HANDBOOK

"You Have What It Takes to Contour and Terrace"

Prepared by Allis-Chalmers engineers in cooperation with the Soil Conservation Service. Pictures and diagrams show practical soil-saving measures with regular farm equipment. You may obtain a copy without charge from your local Allis-Chalmers dealer, or by writing to . . .

ALLIS-CHALMERS

CONSERVATION EDUCATION

(*Continued from page 96*)

Service has soils technicians. The Triple A has money to pay for soil conservation practices.

What the program lacks at the present moment is the educational and organizational drive to get everyone—farmers—schools—city people—all interested in soil conservation. This educational job falls largely on the Extension Service. But Extension needs help in every county in the state so as to be able to mobilize all the forces of the county back of this all important job of soil conservation. Now that the war is over the State should take an aggressive lead in this matter and make the necessary funds available to give extra help. This is the course of wisdom and farsighted statesmanship.

Let us not forget that soil erosion is Iowa's paramount economic problem. Let us not forget that there is a close relationship between soil and people; between soil health and the people's health. We are primarily what we eat. *One of the best ways to develop a strong resourceful people is to provide them with nutritious food. This can only be done if the soil itself is strong and healthful. This is the great objective of soil conservation.*

ECOLOGICAL LAND USE

(*Continued from page 76*)

To explain such reactions we call upon the antibiotic effects between the organisms of the rhizosphere—the fungi and the bacteria—as yet so little understood. But this need not be all. We also have to deal with the fact that many plants are not self-sufficient, they are heterotrophic. By this we mean that just as man must obtain certain amino acids by eating the substance of other animals, in like manner many plants must derive certain essential accessory growth substances from other plants with which they grow in close association. The many grades of such mutualistic effects can only be suggested by making this curt statement without more detail. As a matter of fact, any enlargement upon this statement must unfortunately be altogether too much a matter of speculation. In so far as the nutrition of plants in nature is concerned, we are now exactly where the science of nutrition was when dietitians talked only of carbohydrates, fats, proteins and calories.

If the plant community in which they are growing is impaired through inappropriate agriculture, it is probable that natural foods may be deficient in nutritional substances of protective value (the vitamins). By inappropriate agriculture we mean especially such cultural methods as may injure the organisms which form that portion of the community characteristic of the root zone; in forest soils this may be easily brought about by too liberal use of commercial fertilizer. The same may be true, and there is some evidence for it, in tilled soils.

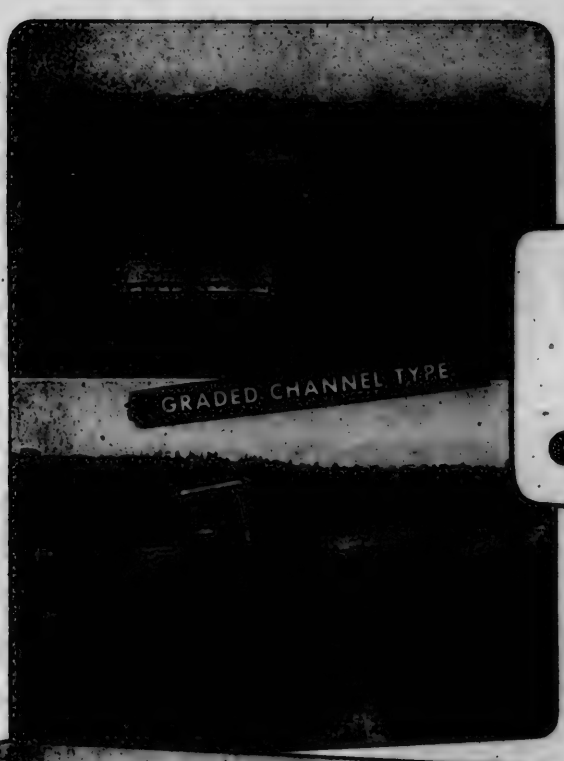
By the same token, for a vigorous, healthy forest community, we must consider the soil flora if a skillful, productive silviculture is to be developed.

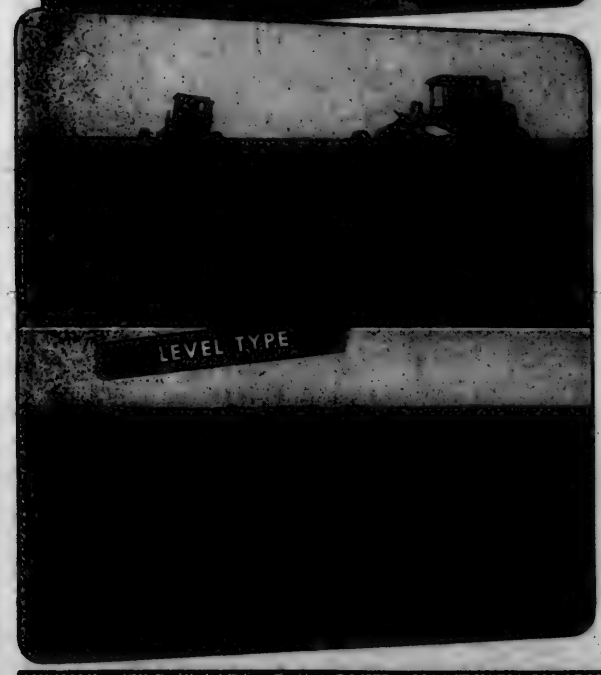
The questions growing out of the problems we have just examined, all too briefly, are of no little importance. There are some who think that the problems here envisaged are possibly even more critical—socially and politically, nationally and internationally—than the questions of public policy raised by the emergent technology of energy derived from the fission of the atomic nucleus.

. . . For a large percentage of the world's population went undernourished before the war as a matter of consistent and deliberate policy and in spite of food surpluses in certain regions. At the same time neglected soil erosion ravaged many rich acres in another way and neither water nor forest resources were properly conserved.

Science knows how to solve . . . the most difficult problems war presented.

That science could as readily solve the cancer, the circulatory disease, and the world food problem, if properly organized and financed, goes without saying. Easiest of these to solve is the last as it requires only the application of scientific knowledge already in the hands of economists, agriculturalists, and experts in nutrition. —SWANN HARDING in June 1946 *Medical Record*.





There's a **JOB** to be done

Terraces to be Constructed

● Whether it is a terrace constructed almost entirely from the upper side, like the New York Diversion Terrace illustrated at the left; or from both sides, like the Texas Level Terrace, also illustrated, the "99-M" Power Grader, with its reversible blade and exclusive All-Wheel Drive and All-Wheel Steer, gets the job done with maximum speed and efficiency. The bulldozer attachment is used to excellent advantage wherever terrace lines are crossed by small gullies, and has so many other time and labor-saving uses as to make it a worthwhile addition to almost every terracing outfit.

Millions of acres in the United States have already been anchored effectively against erosion. We are moving ahead, and the modern Power Grader is playing an important role in conquering the time element. We would welcome the opportunity to tell you more about its many uses in Soil and Water Conservation.

AUSTIN-WESTERN COMPANY
Aurora, Illinois, U.S.A.

BUILDERS OF ROAD MACHINERY SINCE 1859

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CONSERVATION
Calls for Selling

HOW fast America adopts soil conservation measures depends mainly on how well and how widely the merits and rewards of conservation are sold. Only when the idea is sold to the point of arousing action does conservation come to reality.

This Company believes in selling a good idea by showing how equipment can be used to put the idea into practice. Such selling gets action, not merely academic acceptance. Hence the promotional and educational activities of this Company seek to sell the USE of tractors and implements for making conservation improvements and for farming by conservation methods.

Case advertising has urged soil conservation measures in a well-rounded program of advanced farm practices. Case has prepared a series of full-color sound movies, plus a parallel series of attractively printed educational booklets and wall charts promoting these practices. All are freely available to any agencies who can put them to good use.

Some of the subjects are pond building, contour farming, terracing with moldboard and one-way disk plows; also the production of high-protein hay which paves the way for grassland farming and soil-saving rotations. You are invited to send for sample booklets and for full information on films, posters, and other educational material.

J. I. Case Co., Racine, Wis.

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